



Chimborazo

The World's Highest Mountain

Andy French, Studium 2015

1. Why is Chimborazo the world's highest mountain?
2. A bit about spherical coordinates
3. Guatemala's Magnificent Seven
4. A very brief introduction to volcanoes
5. Ecuador's Triple Crown
6. Some atmospheric physics
7. Why go mountaineering?
 - Kilimanjaro
 - Annapurna Sanctuary
 - Snowdonia & Scotland
 - Haute Route
 - Mont Blanc
 - Toubkal
 - Corsica GR20
 - Monte Rosa





erva de
ucción
ística
borazo



Chimborazo
(6310m)

- *Veintemilla summit is 6267m
- *Whymper summit is 6310m

Why is Chimborazo the world's highest mountain?

WGS-84 ellipsoid

Equatorial radius (6,378.1370 km)

Polar radius (6,356.7523 km)

Difference between polar and equatorial radius is

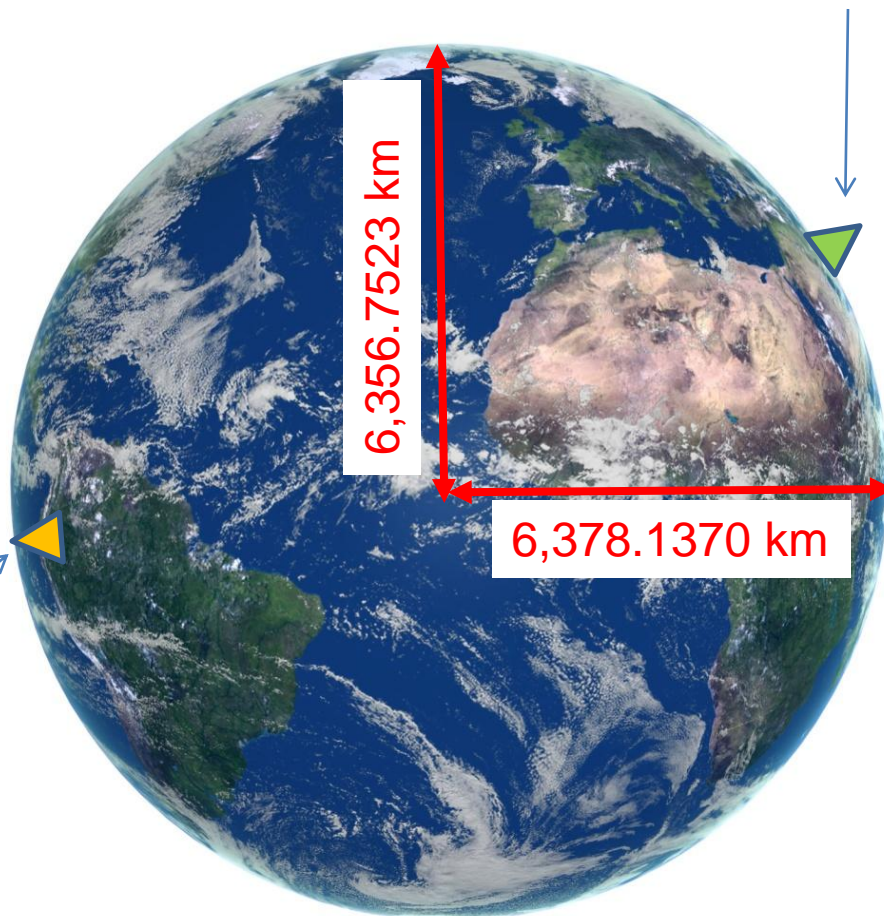
21.3847 km

So Chimborazo is the highest mountain in the world! *

**from the Earth's centre*



Mount Everest, Nepal (8848m)



Chimborazo, Ecuador (6310m)

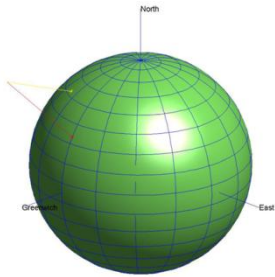
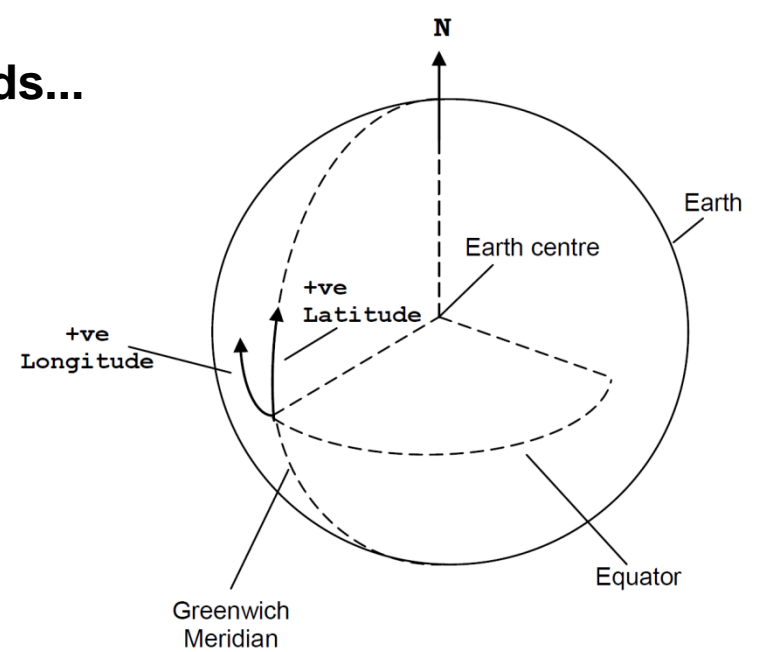


A bit about spherical coordinates and ellipsoids...

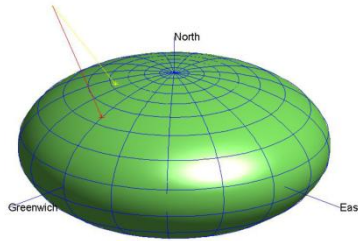
$$R_f = (1 - f)R_e$$

$$R_e = 6.378137 \times 10^3 \text{ km}$$

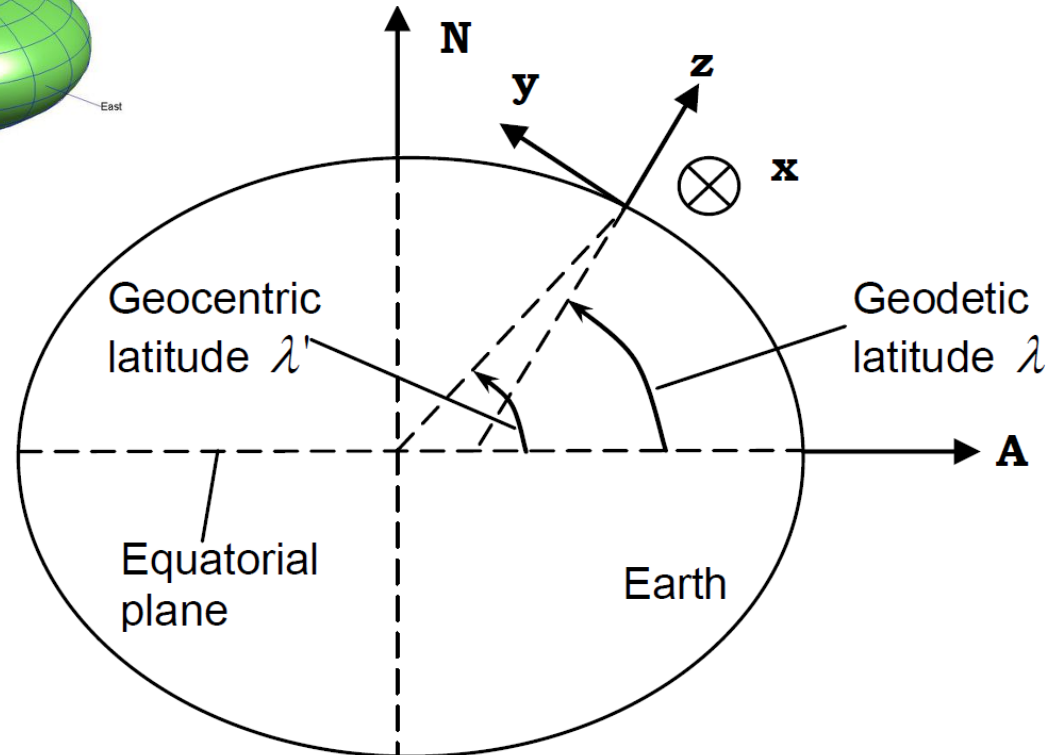
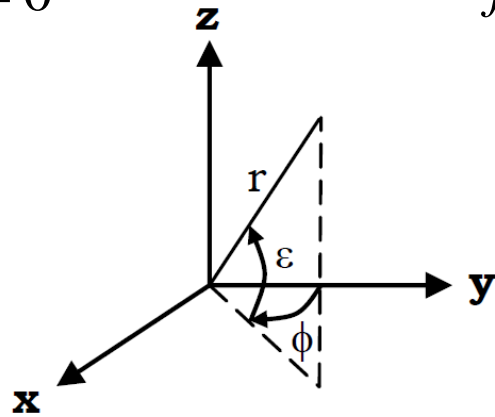
$$f = 1/228.257223563$$



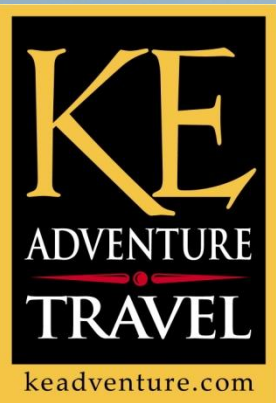
$$f = 0$$



$$f = \frac{1}{2}$$



Range, azimuth and elevation

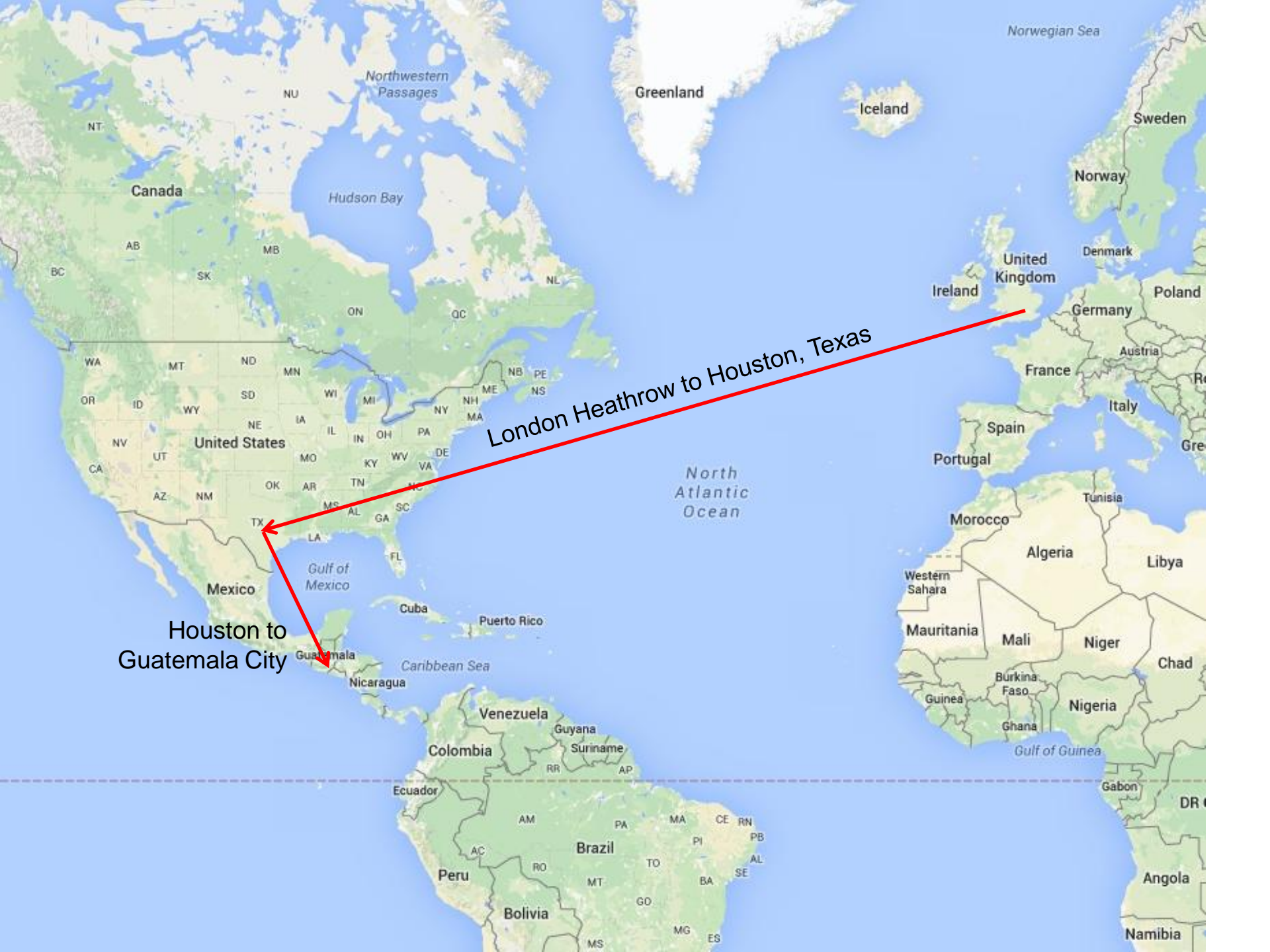


Trip code GVO

Guatemala's Magnificent Seven

December 2014



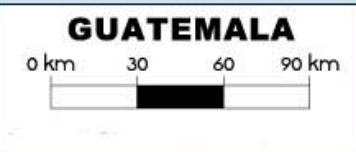


London Heathrow to Houston, Texas

Houston to
Guatemala City

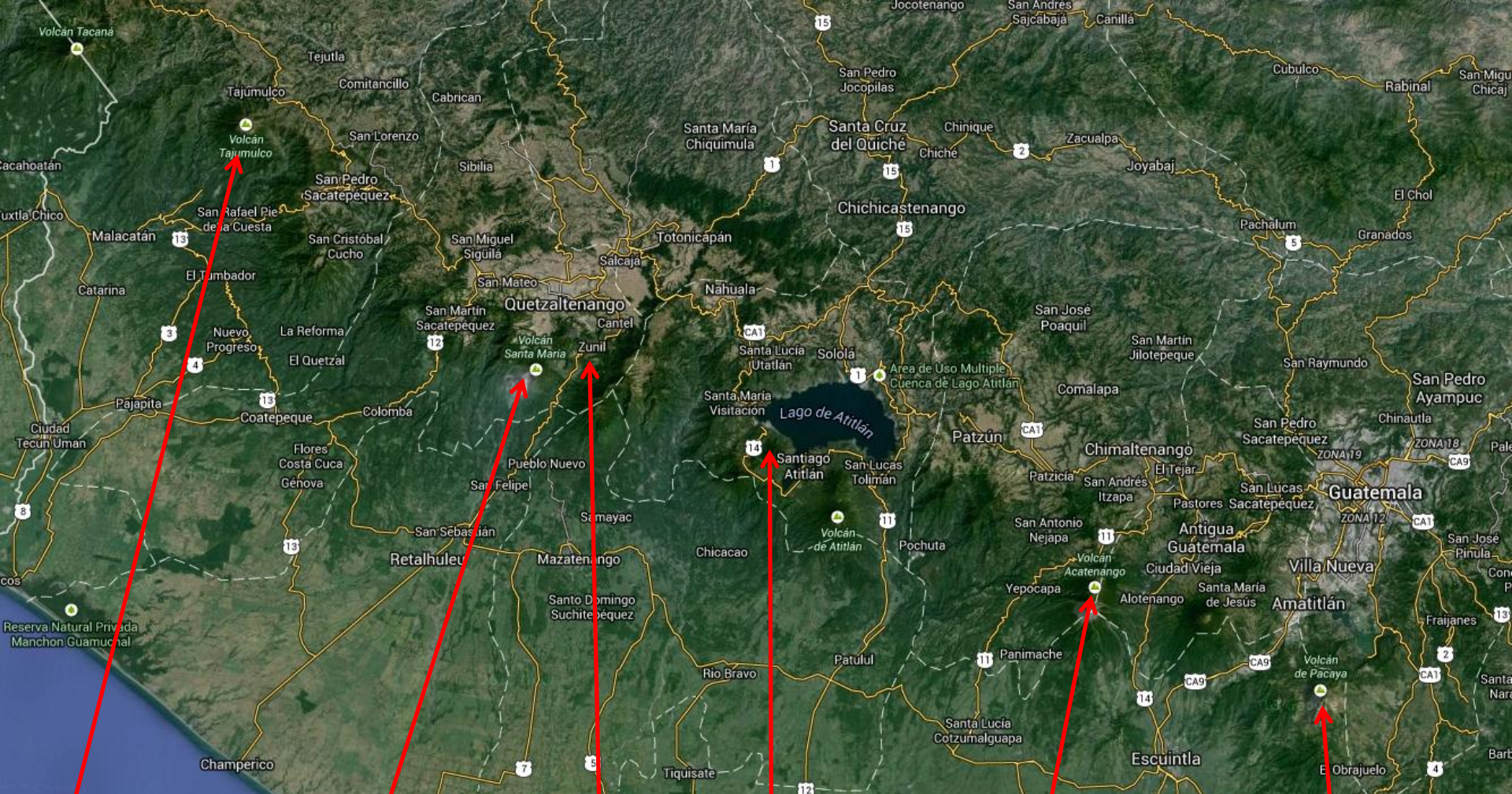


- 1 HUEHUETENANGO
- 2 SAN MARCOS
- 3 QUEZALTENANGO
- 4 TOTONICAPÁN
- 5 BAJA VERAPAZ
- 6 EL PROGRESO
- 7 ZACAPA
- 8 CHIQUIMULA
- 9 JALAPA
- 10 GUATEMALA
- 11 SACATEPÉQUEZ
- 12 CHIMALTENANGO
- 13 RETAHULEU
- 14 SUCHITEPÉQUEZ
- 15 ESCUINTLA
- 16 SANTA ROSA
- 17 JUTIPIA



PACIFIC OCEAN





Tajumulco
(4220m)

Santa Maria
(3770m)

Zunil
(3542m)

San Pedro
(3020m)

Acatenango
(3976m)
Fuego*
(3763m)

Pacaya*
(2552m)

*Active!

In climbing order: Pacaya, Acatenango, Fuego, Zunil, Santa Maria, Tajumulco, San Pedro



Zunil



Tajumulco



Fuego



Santa Maria

Zunil campsite



San Pedro





Mario

The trekkers!

Licette

Welber



Andy



Ray



Graham

Jane

Bocadia

Trish

Antigua





Antigua culture!





Volcan Pacaya





Fuego and Acatenango



Fuego erupts!



Agua volcano, viewed from the campsite terrace of Acatenango





Volcan de Agua (3760m)



Summit of Acatenango at dawn





Ascent of Fuego



Waiting for an eruption!







Hey pretty one....



The wonderful art deco Hotel Modela in Quetzaltenango





Beauty and tragedy on
the Siete Cruces trail
on Volcan Zunil

Summit shrine





Agua, Acatenango, Fuego, Toliman, Atitlan & San Pedro viewed from
Volcan Zunil campsite









Descent from Zunil to the hot springs at Fuentes Georginas





Santa Maria, and its active companion Santiaguito



Tostados!



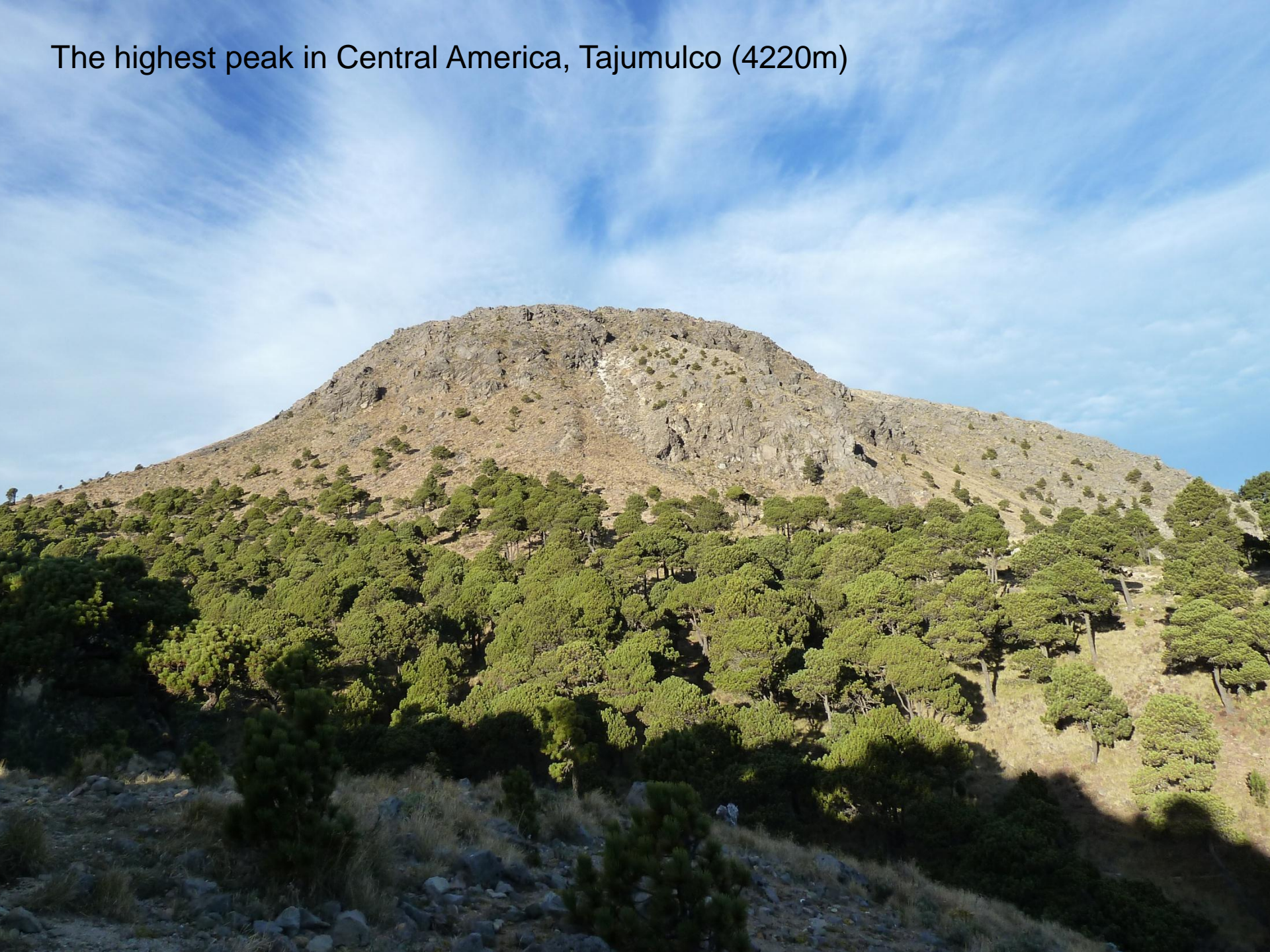
Llanos del Pinal



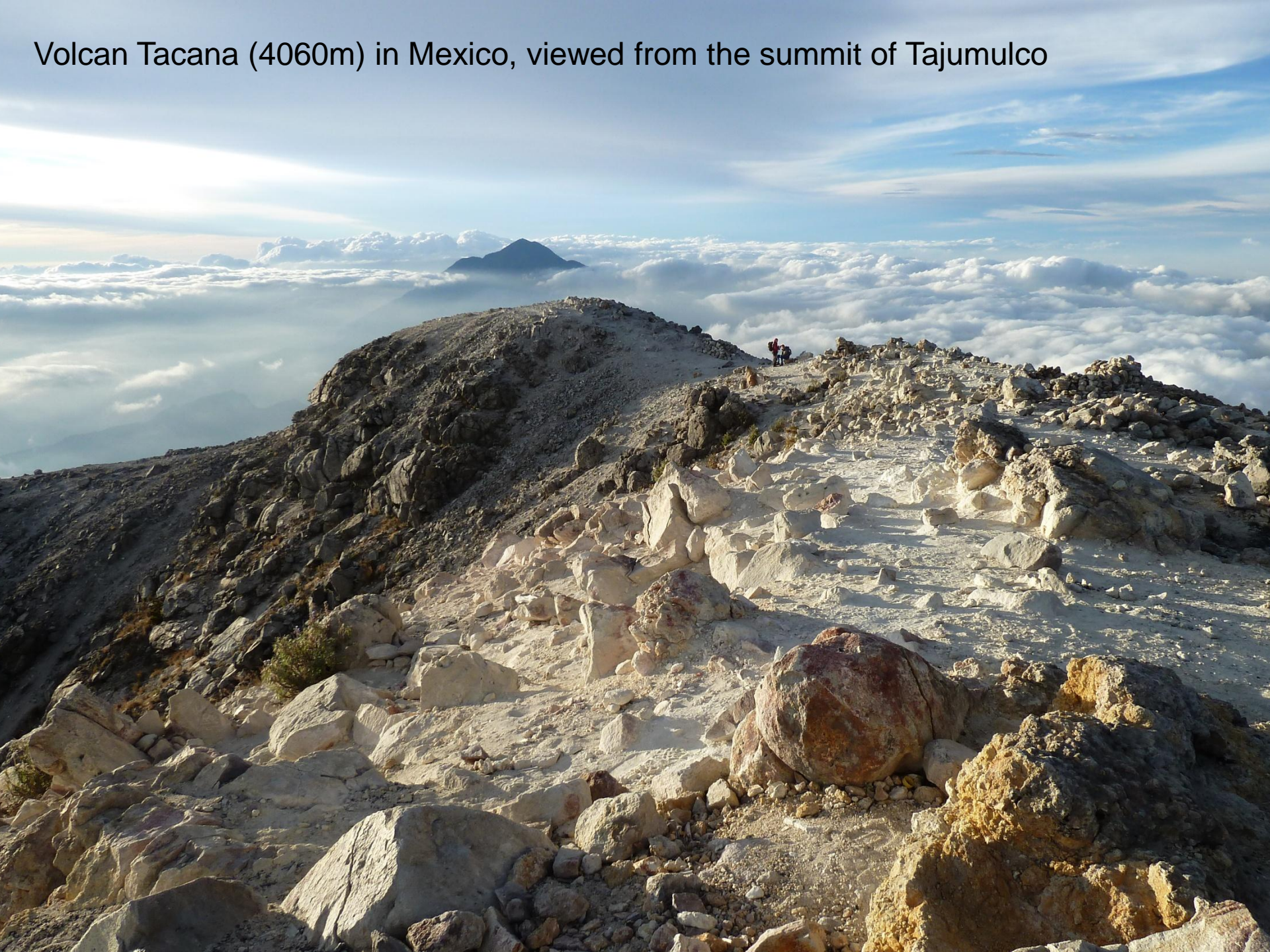
Descent of Santa Maria towards Quetzaltenango ('Xela')



The highest peak in Central America, Tajumulco (4220m)

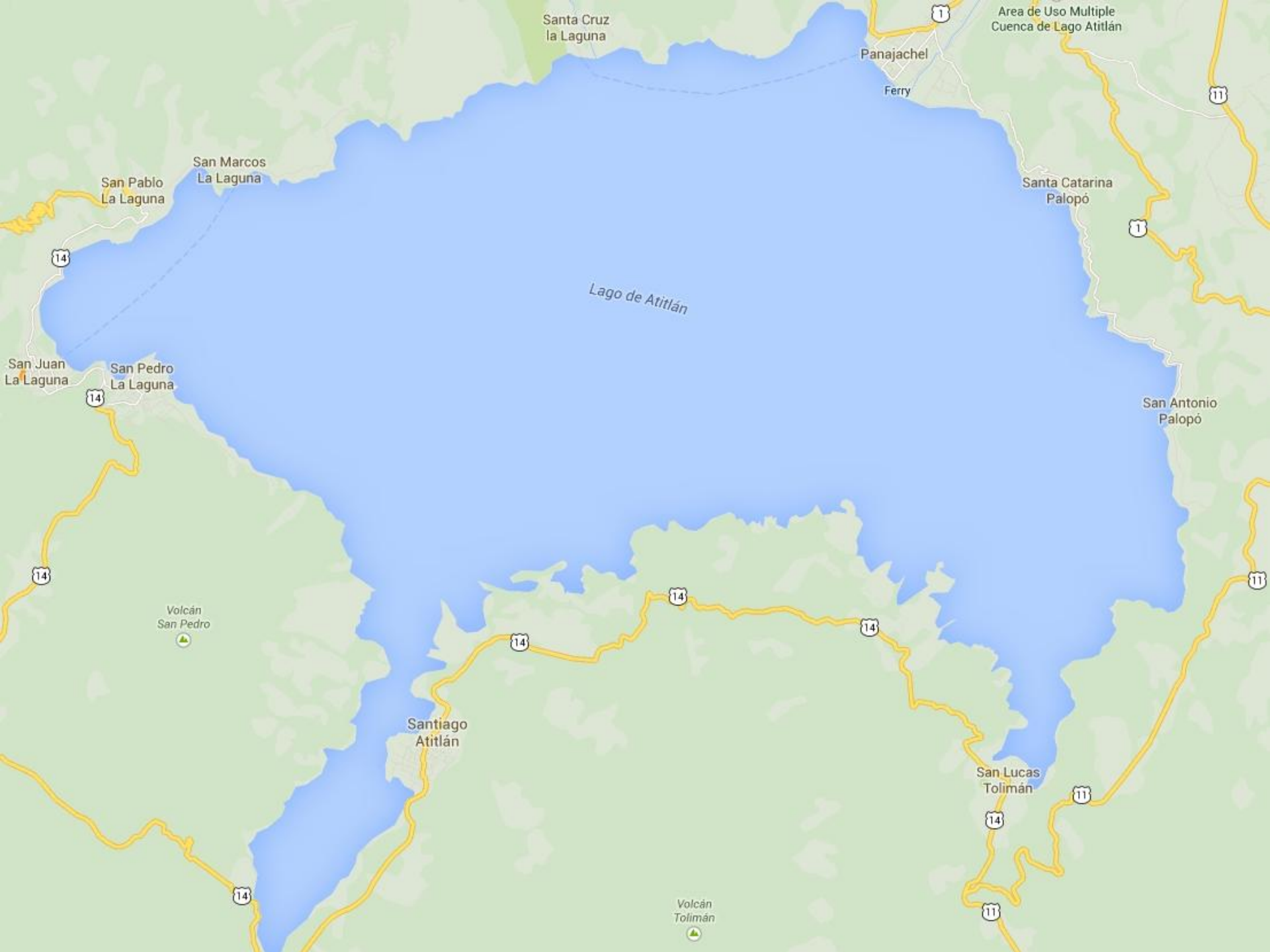


Volcan Tacana (4060m) in Mexico, viewed from the summit of Tajumulco









Santa Cruz la Laguna

Area de Uso Múltiple Cuenca de Lago Atitlán

Panajachel
Ferry

Santa Catarina Palopó

San Marcos La Laguna

San Pablo La Laguna

Lago de Atitlán

San Antonio Palopó

San Juan La Laguna

San Pedro La Laguna

Volcán San Pedro

Santiago Atitlán

San Lucas Tolimán

Volcán Tolimán



Panajachel (or Gringoland!) on Lake Atitlan







R & R at last...



Climb of San Pedro on Christmas Day







EL TUCAN

BOOM BURST



Christmas *tamales* for
Welber and Mario



Feliz Navidad in
San Pedro de la Lacuna



Tolimán, Atitlán and San Pedro as viewed from Casa Mundi




WATCH YOUR HANDS AND FEET
When getting on and out of a boat.
CUIDADO CON LAS MANOS Y PIES
Al subir o bajar de un bote.

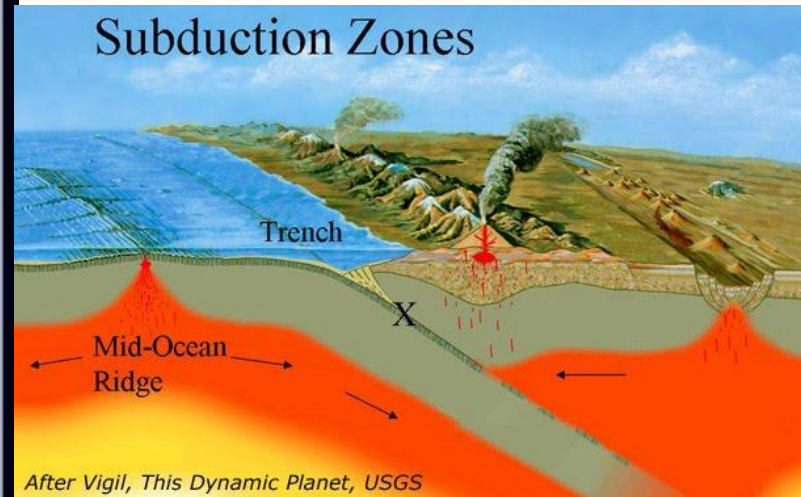
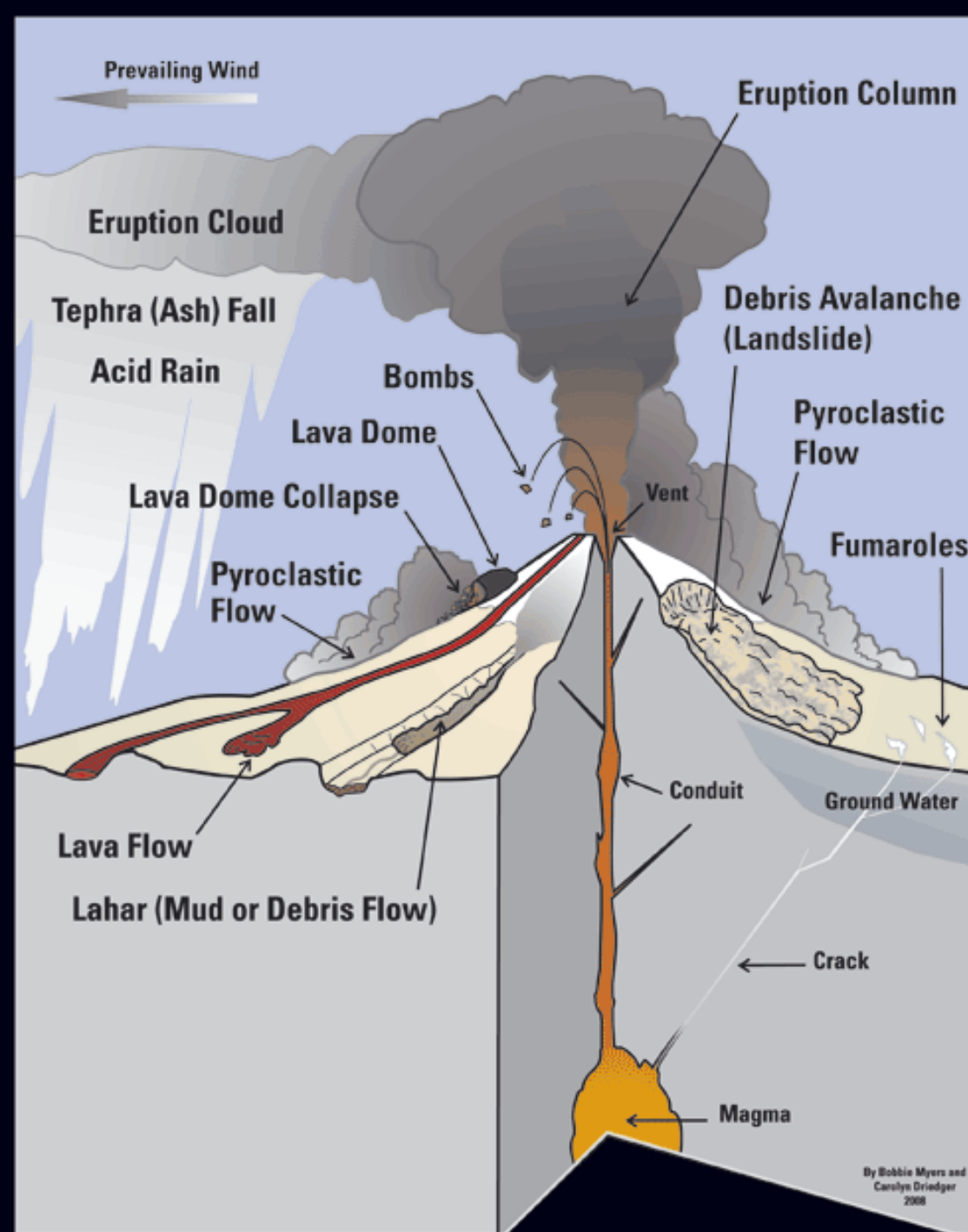
Adios Lake Atitlan....



Adios Guatemala!

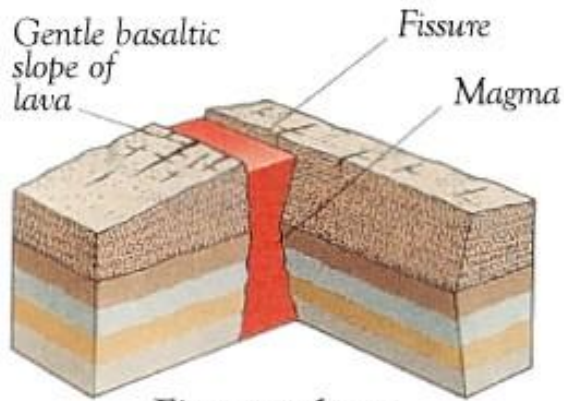


A very brief introduction to **volcanoes**

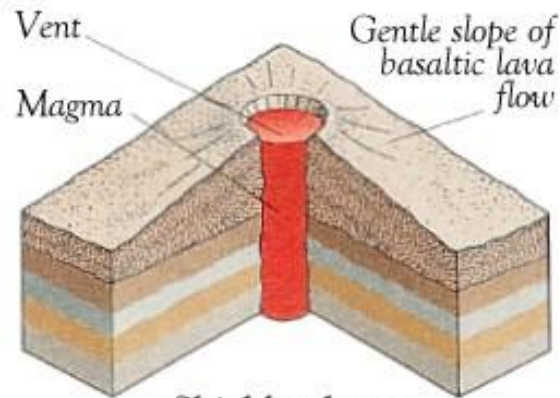


<http://photography.nationalgeographic.com/photography/photo-of-the-day/fuego-volcano-guatemala/>

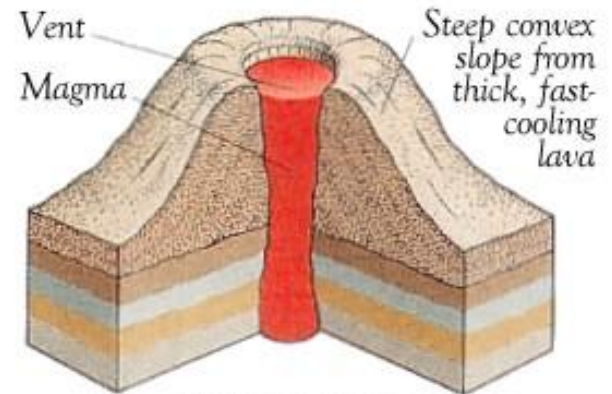
TYPES OF VOLCANO



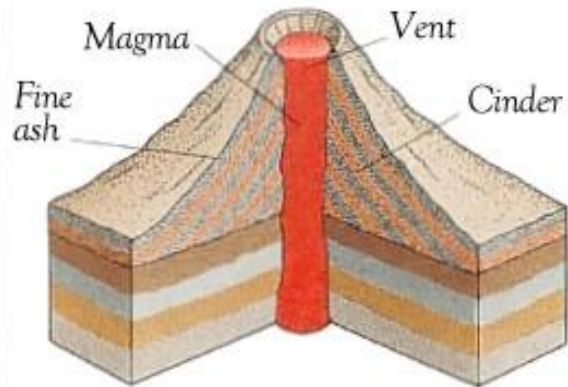
Fissure volcano



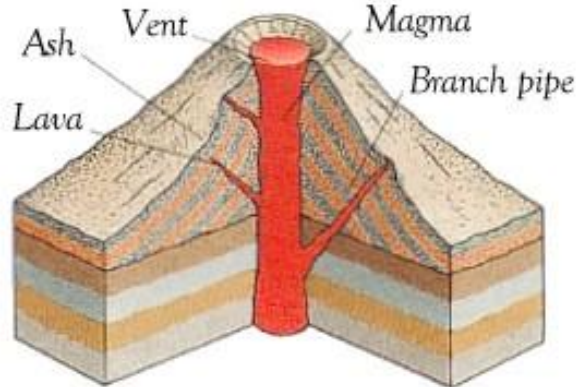
Shield volcano



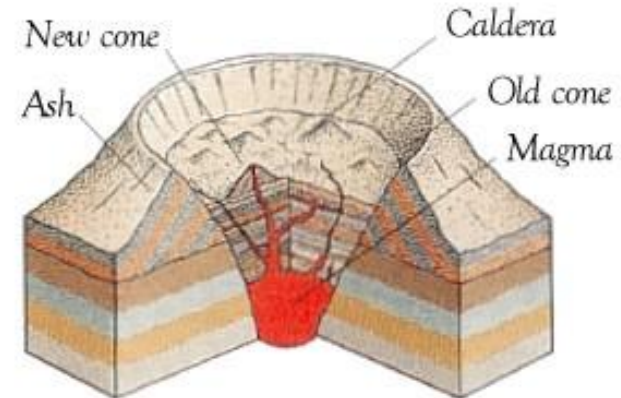
Dome volcano



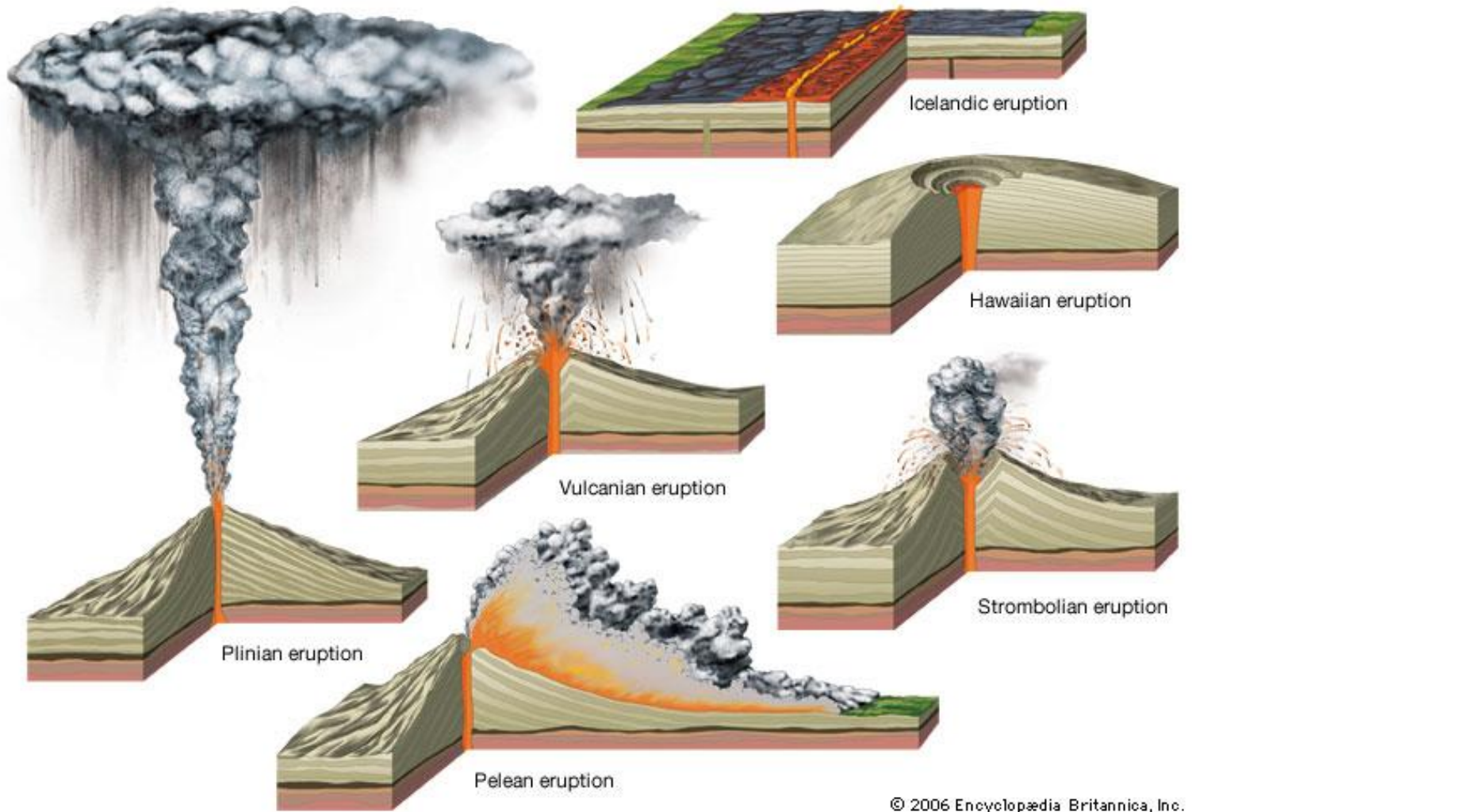
Ash-cinder volcano



Composite volcano



Caldera volcano



Icelandic eruption

Hawaiian eruption

Vulcanian eruption

Strombolian eruption

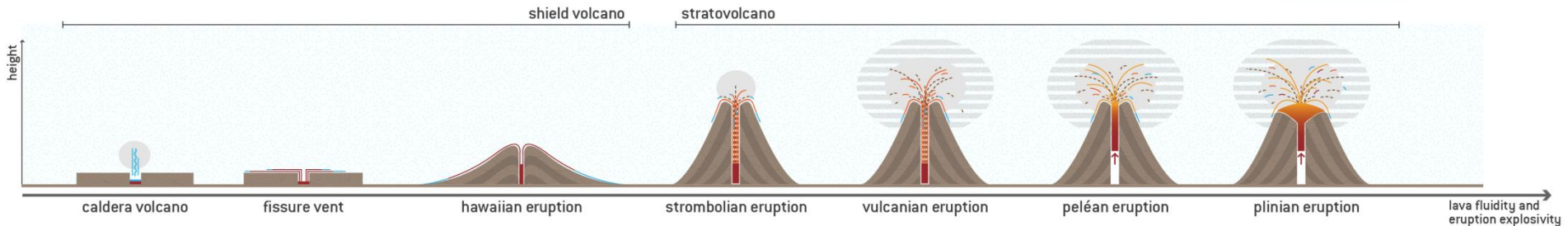
Plinian eruption

Pelean eruption

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- fluid lava flow
- viscous lava flow
- cooled lava
- volcanic gases
- gas clouds
- volcanic ash

volcano structure



caldera volcano

fissure vent

hawaiian eruption

strombolian eruption

vulcanian eruption

peléan eruption

plinian eruption

lava fluidity and eruption explosivity



KE

ADVENTURE
TRAVEL

keadventure.com

Trip code ECU

Ecuador's Triple Crown

Andy French. December 2015

Team KE: Ecuador's Triple Crown. Friday 18/12/15 – Saturday 2/1/16

Fergal

Mark

John

Kent

Andy



Nelson

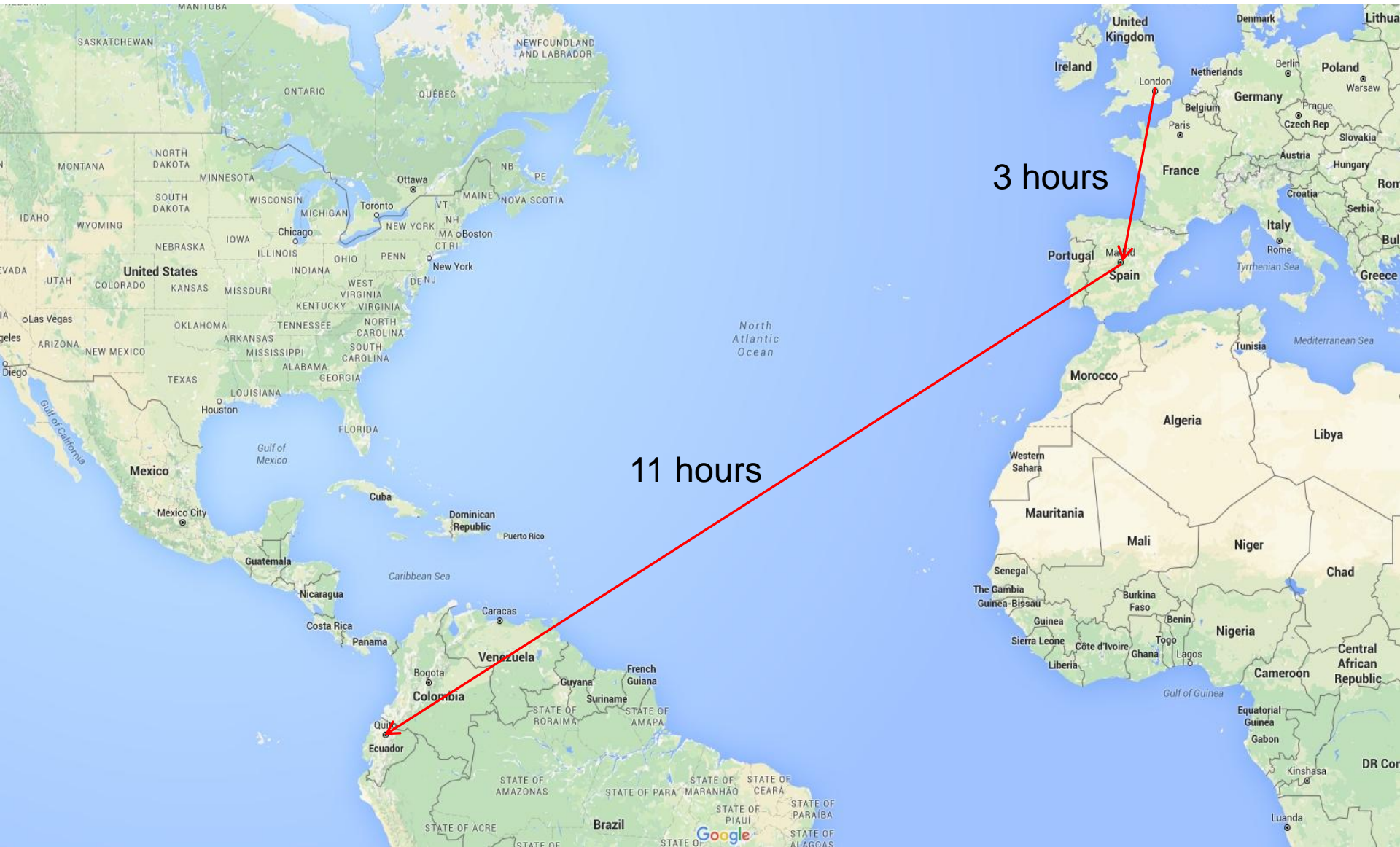
Diego

Nicola



Trip code ECU

Fly (BA / Iberia) London Heathrow to Quito, via Madrid





Ecuador

Population:
16.1 million (2015)

Area:
283,560 km²

GDP:
\$180.2 billion
(65th /196)
(\$11,244 per capita)



144km



Quito

Cayambe

Cotopaxi

Banos

Chimborazo

Riobamba

Google

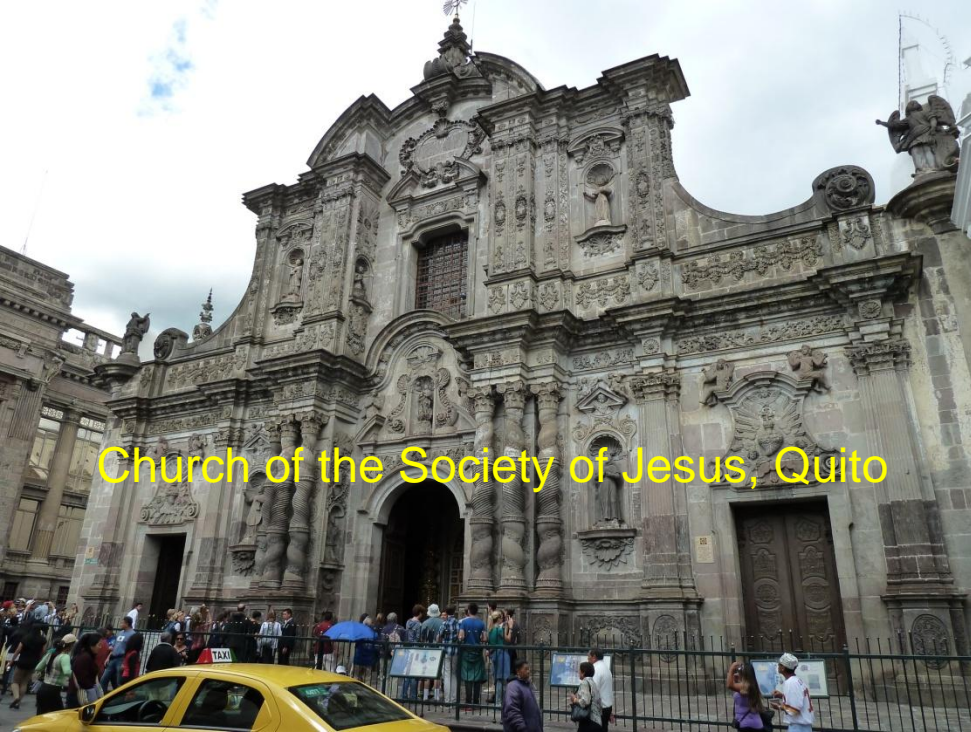
Quito. Capital city of Ecuador. Population 1.6 million.
(Quito is the second largest city. The largest by population is Guayaquil at 2.3 million)



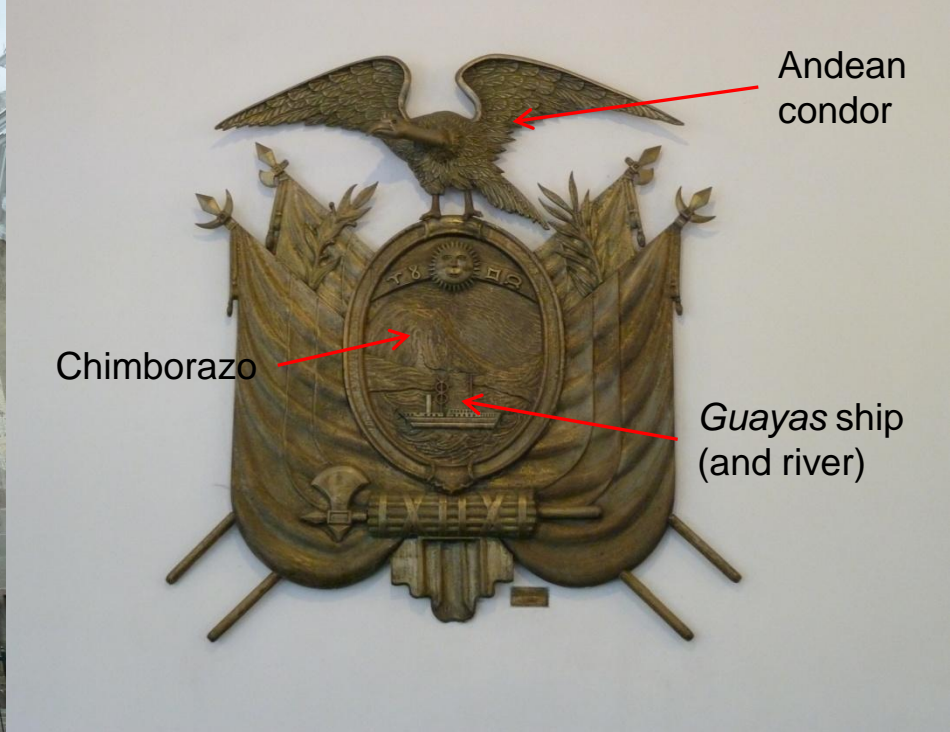


Madonna atop El Panecillo volcanic hill.
7000 pieces of aluminium!
(Agustín de la Herrán Matorras, 1976)





Church of the Society of Jesus, Quito



Andean condor

Chimborazo

Guayas ship (and river)



Palacio de Carondelet (seat of government)



Independence square

Colombian restaurant



Mark eating Cuy (guinea pig)





Acclimatisation walk
around Culcocha crater lake (3500m)



Feliz Navidad in San Francisco (Ecuador!)

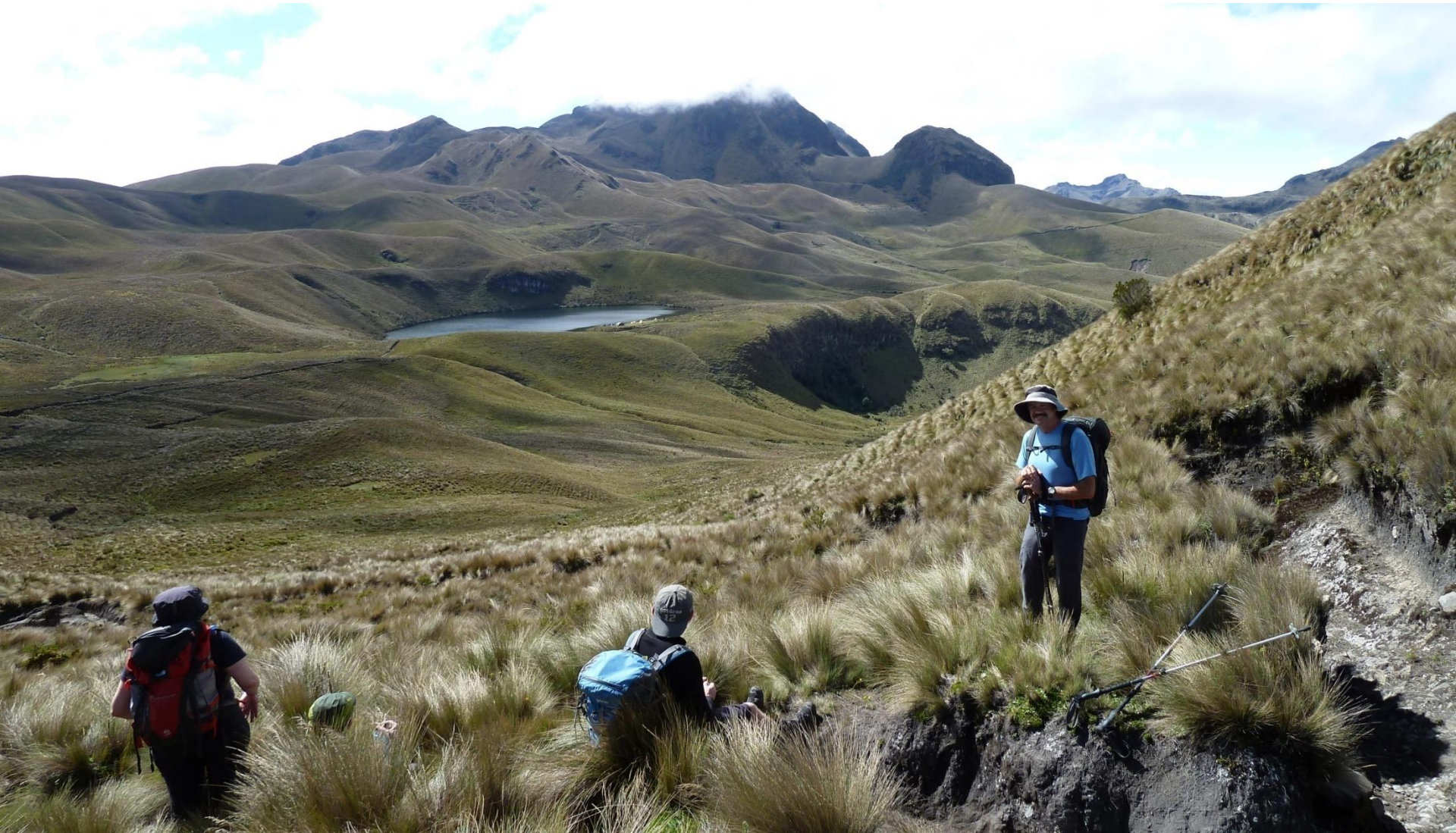




Full service camping on the village soccer pitch

Acclimatisation trek (2500m to > 4000m) in Cotacachi-Cayapas reserve.

Cotacachi-Cayapas reserve. Camp at Yanacocha lake



Camp at Yanacocha lake (3870m)







Imbabura (4609m)



Chachimbito thermal springs



Climb of volcano Imbabura (4609m) on Christmas Eve







San Clemente homestay





San Clemente homestay

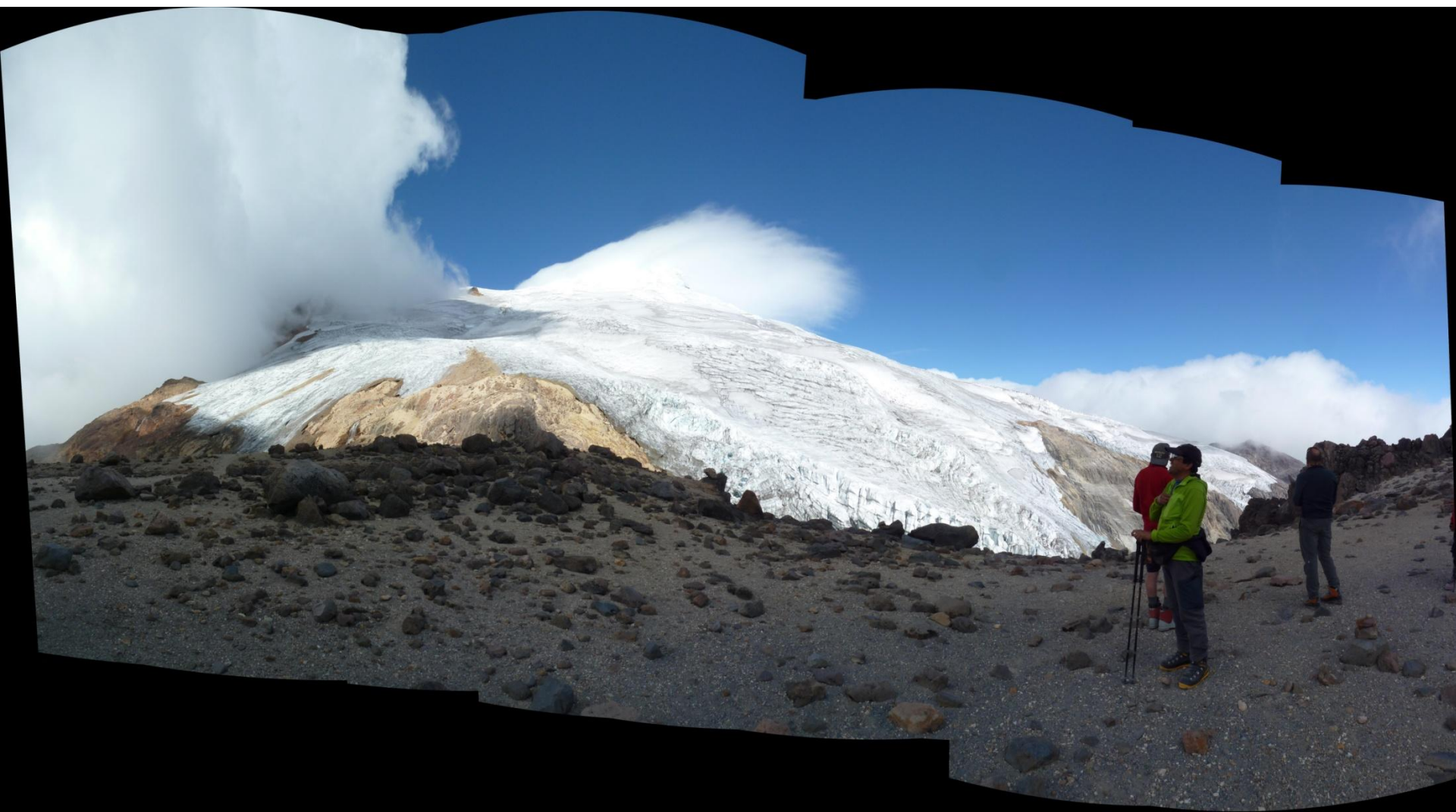


Cayambe town biscuit factory



Cayambe (5790m)





Cayambe (5790m). Hermoso glacier

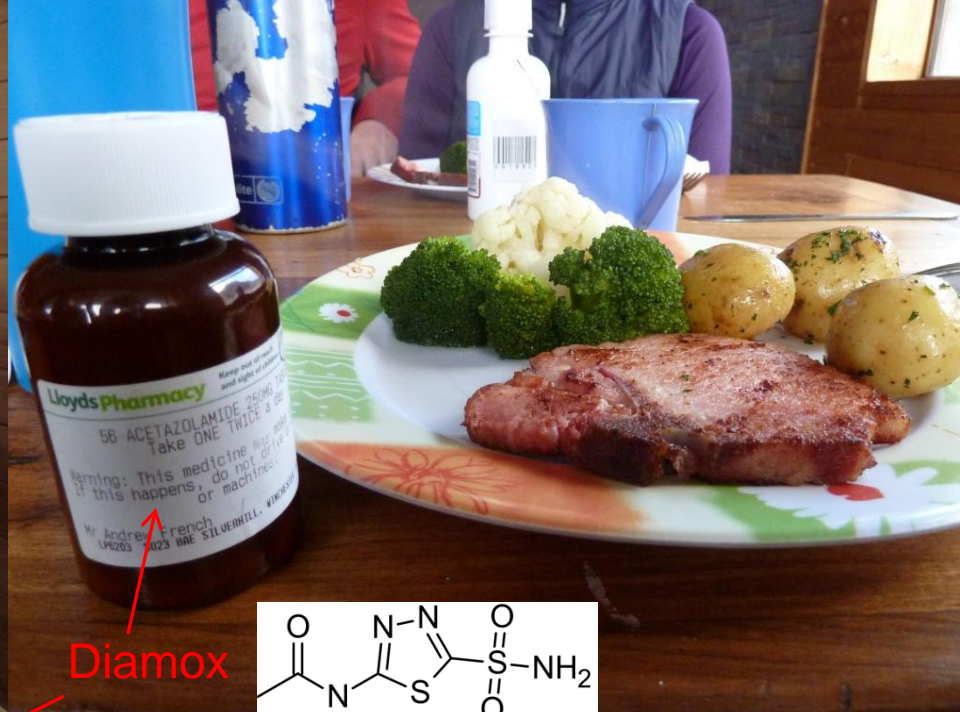
Cayambe (5790m). Hermoso glacier.
Christmas Day 2015



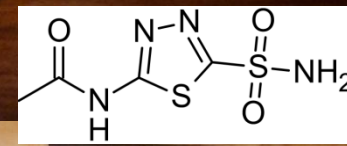








Diamox



“.....blood becomes acidic, causing compensatory hyperventilation, increasing levels of oxygen and decreasing levels of carbon dioxide in the blood” (Wikipedia)



Bergé, Ruales, Oleas refuge (4650m).



Summit attempt at 23:00. Abandoned at lower glacier (5000m) due to bad weather. Returned to refuge about 04:30

Cable car to the Pichincha viewpoint above Quito (4050m)





Several 12 Megapixel digital photo images (taken using a Panasonic Lumix TZ8 in fixed focus 'panoramic' mode) *stitched* using [Microsoft Image Composition Editor](#) (ICE)





Cotopaxi (5895m)





Sawdust filled dummies to be burnt as "los años viejos" (the old years) at midnight on New Year's Eve

Chimborazo (6310m)



Estrella del Chimborazo (Chimborazo lodge).
A homage to mountaineering history!





Arid desertscape in the rain-shadow to the west of Chimborazo

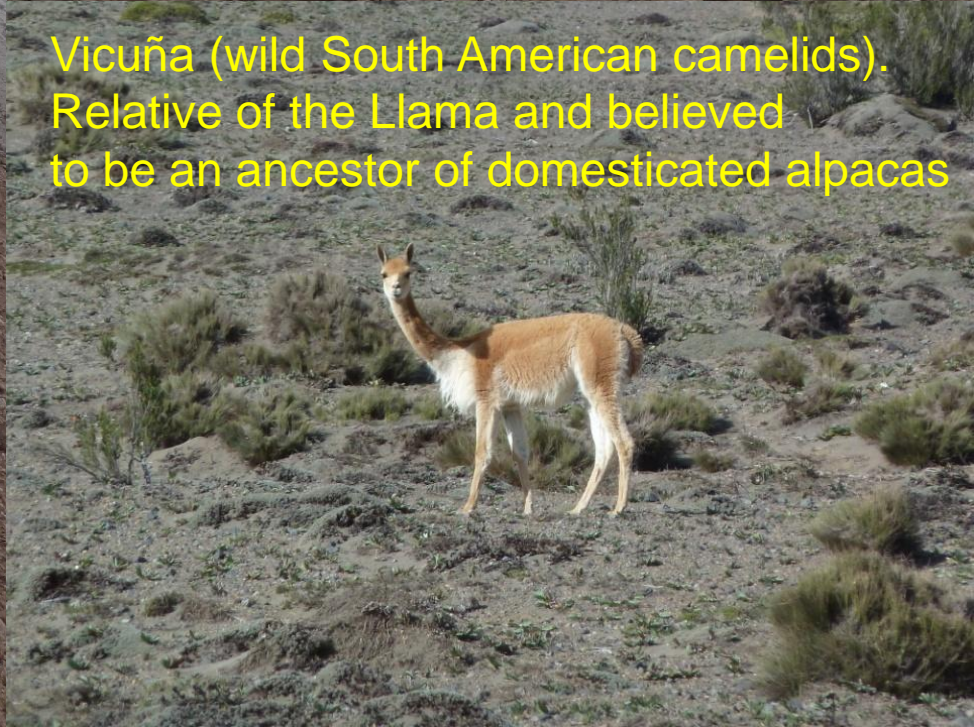


Acclimatisation walk to 5350m from Refugio Carrel





Vicuña (wild South American camelids).
Relative of the Llama and believed
to be an ancestor of domesticated alpacas







Alpacas

Strata of deposition from Chimborazo, revealed by a road cut into the hillside. Layers indicate past eruptions and or landslides. The thickness of the layers gives an indication of the relative magnitudes of such geological events



Chimborazo (6310m)



Whympers hut (5000m)





The track from the Carrel hut (4850m) to the Whymper hut (5000m)



Sunset at the Carrel hut,
Chimborazo.

An early dinner, then rest before
summit attempt at 22:45....



Dawn breaks on Chimborazo. High on the glacier (around 6000m)



Since the sun is rising in the east, Chimborazo casts a shadow upon the westerly cloud inversion

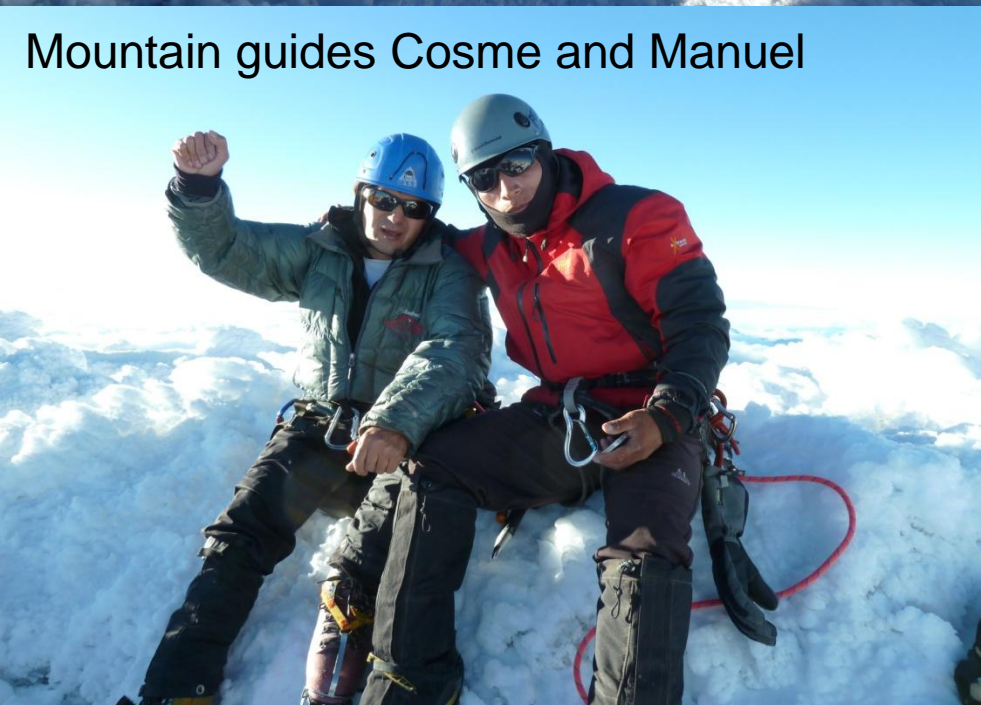




Andy, Fergal and Kent reach the summit of Chimborazo



Veintemilla summit (6267m) reached around 7am on New Year's Eve



Mountain guides Cosme and Manuel





The Whymper summit of Chimborazo (6310m). The furthest point from the centre of the Earth, and closest to the stars



Edward Whymper
1840-1911
First Ascent of the Matterhorn in
Zermatt, Switzerland



Mountain
guide Manuel



Wind formed ice *penitentes*



Crampons in contact with the ice at all
times!





Traversing the glacier and avoiding crevasses



The Traverse and El Castillo (The Castle)

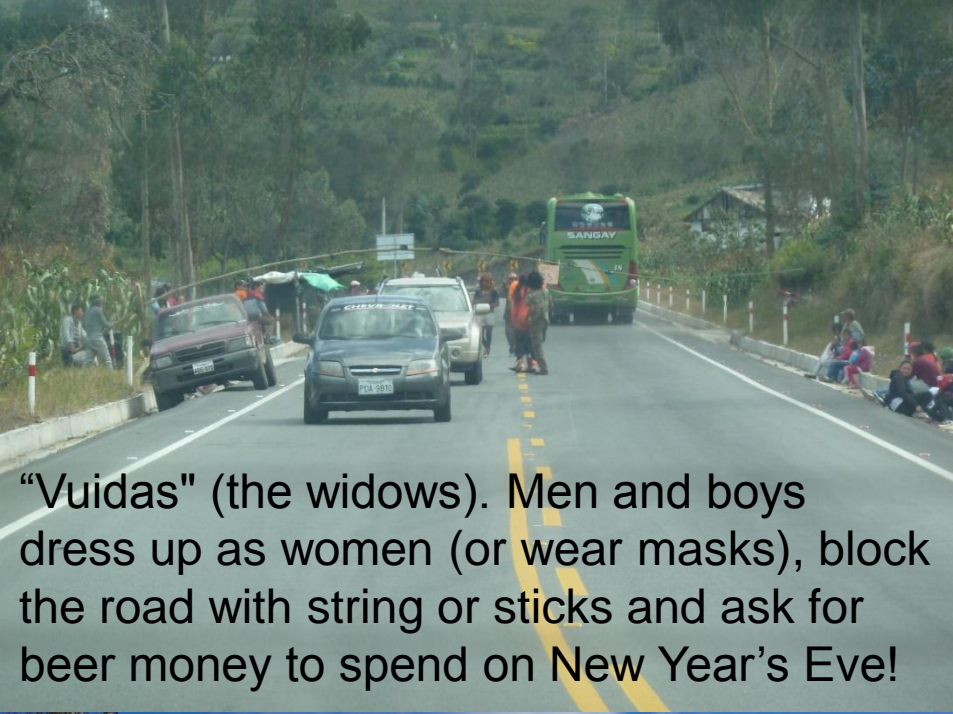




Route to the Veintemilla summit (6267m) of Chimborazo from The Traverse







“Vuidas” (the widows). Men and boys dress up as women (or wear masks), block the road with string or sticks and ask for beer money to spend on New Year’s Eve!



Active volcano Tungurahua (5023m)



Zip line and Via Ferrata in Banõs



After 800m of forward facing zip line into a canyon....





An alternative New Year's Day 'hangover' (!)



Pailon del Diablo (Devil's Cauldron)
waterfall in Banõs



Pailon del Diablo (Devil's Cauldron) waterfall in Banõs



Final KE team meal in the Beach Bar, Quito

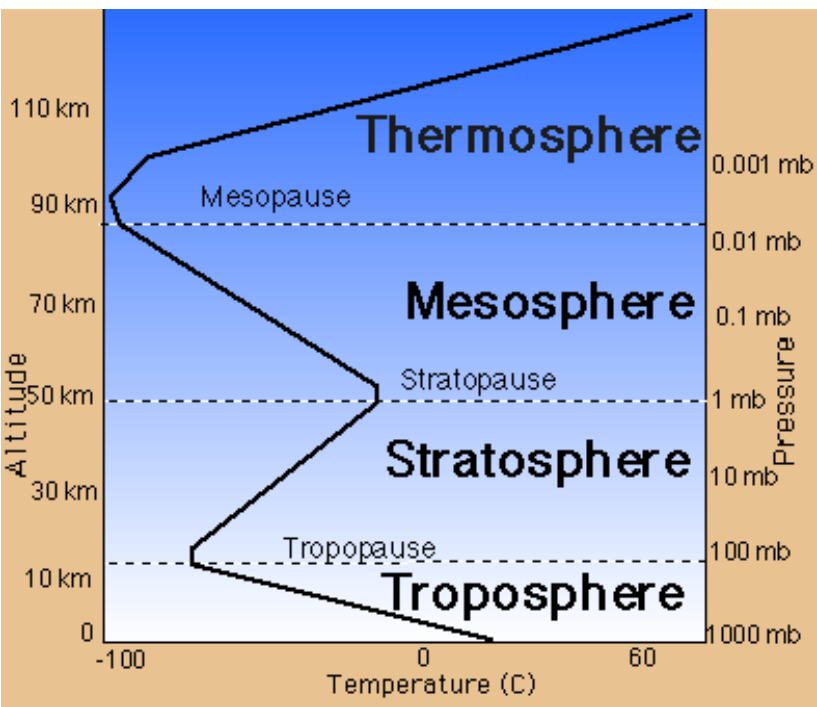
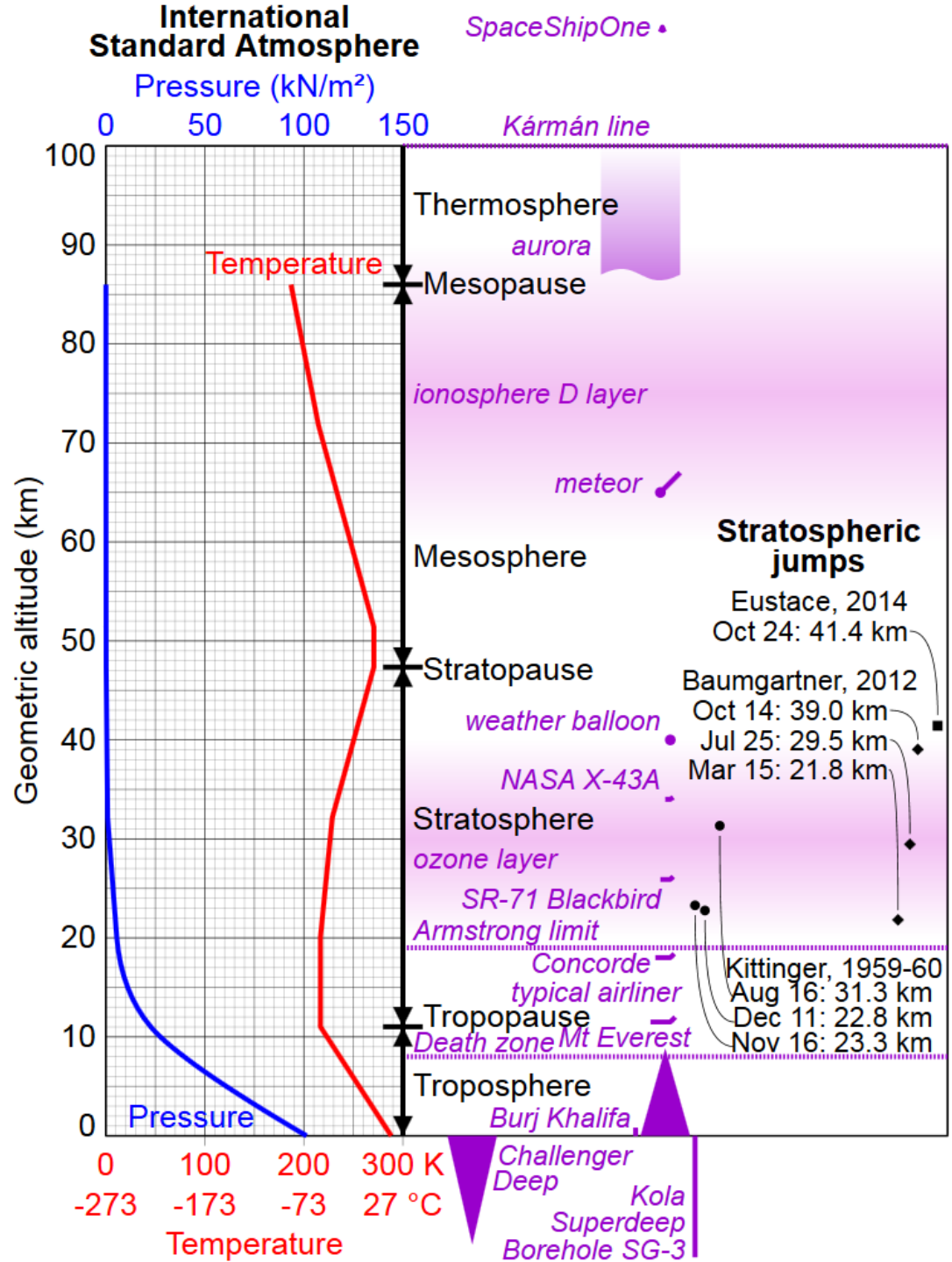


Fergal, Andy and Mark climb Pichincha (4696m)



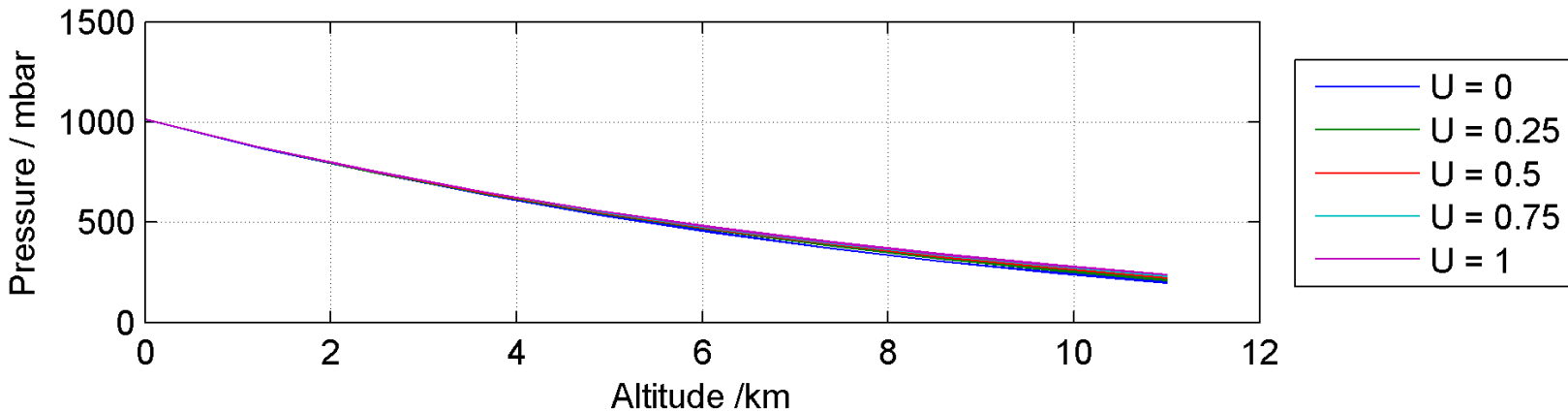
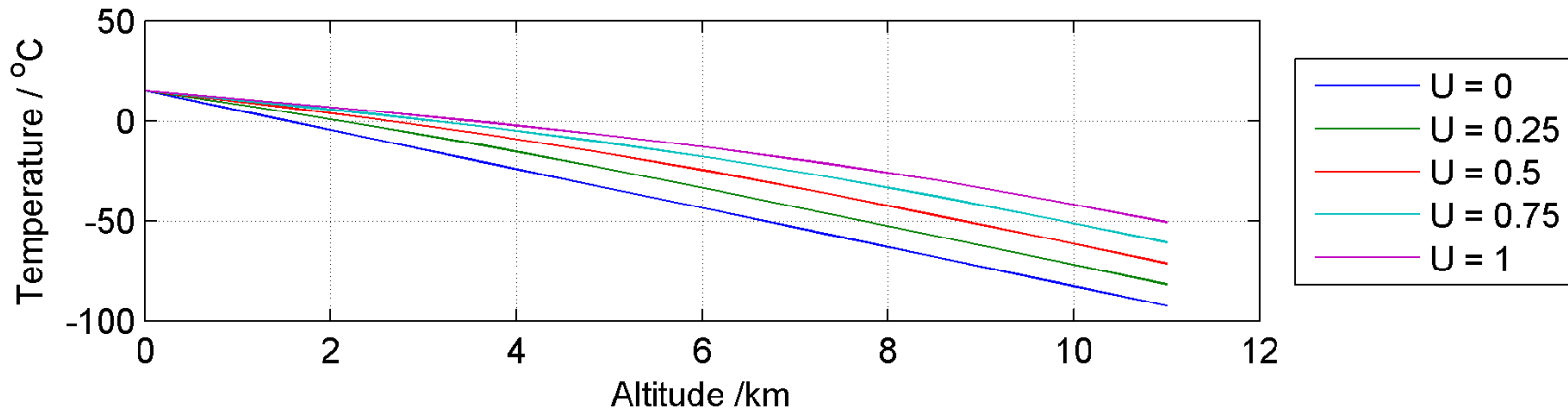
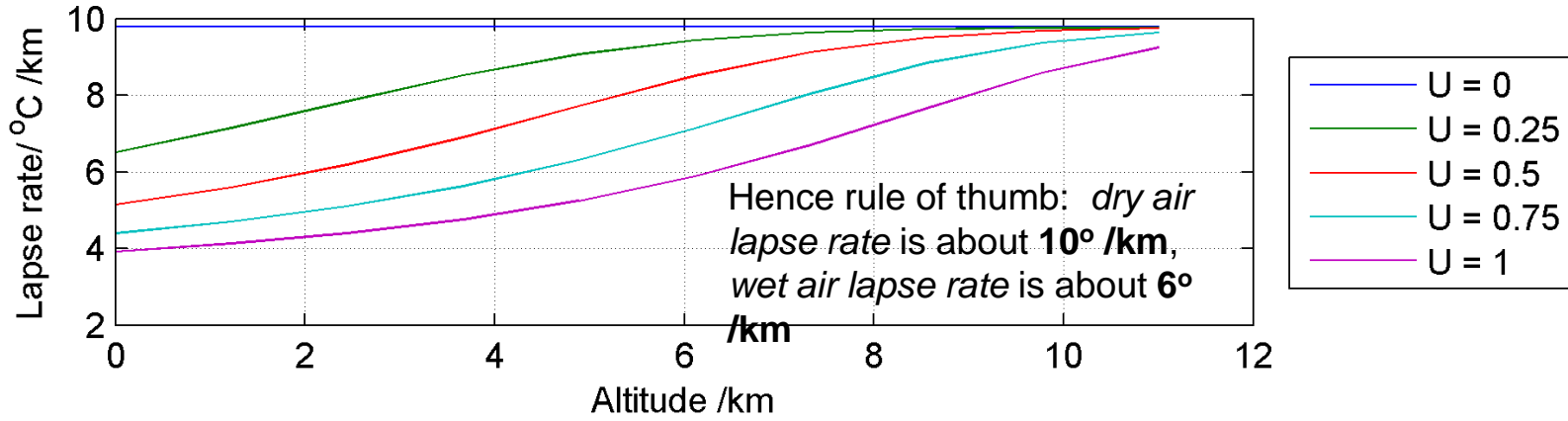
And now for some atmospheric physics!

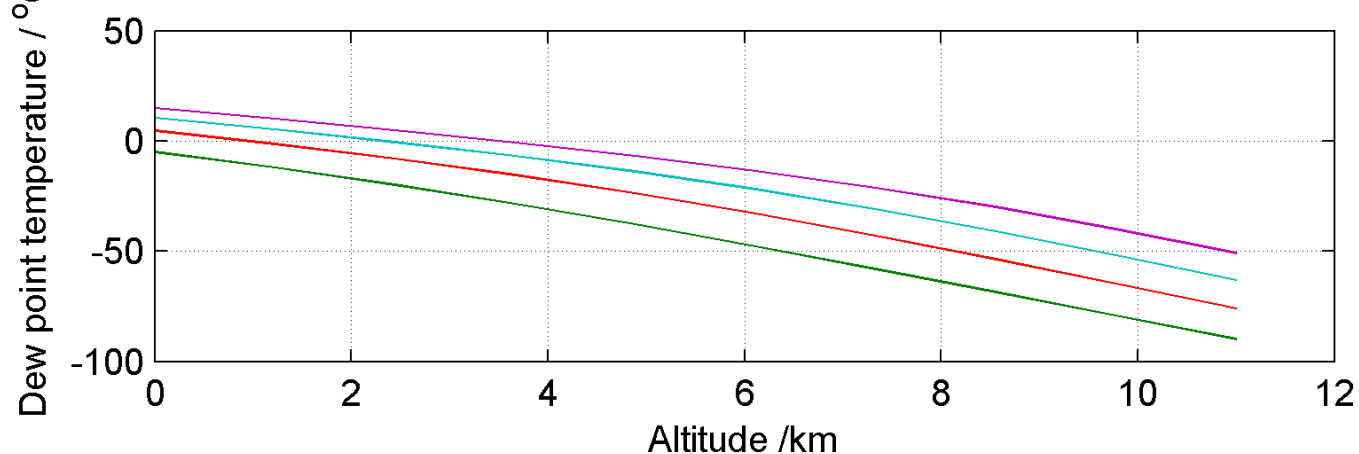
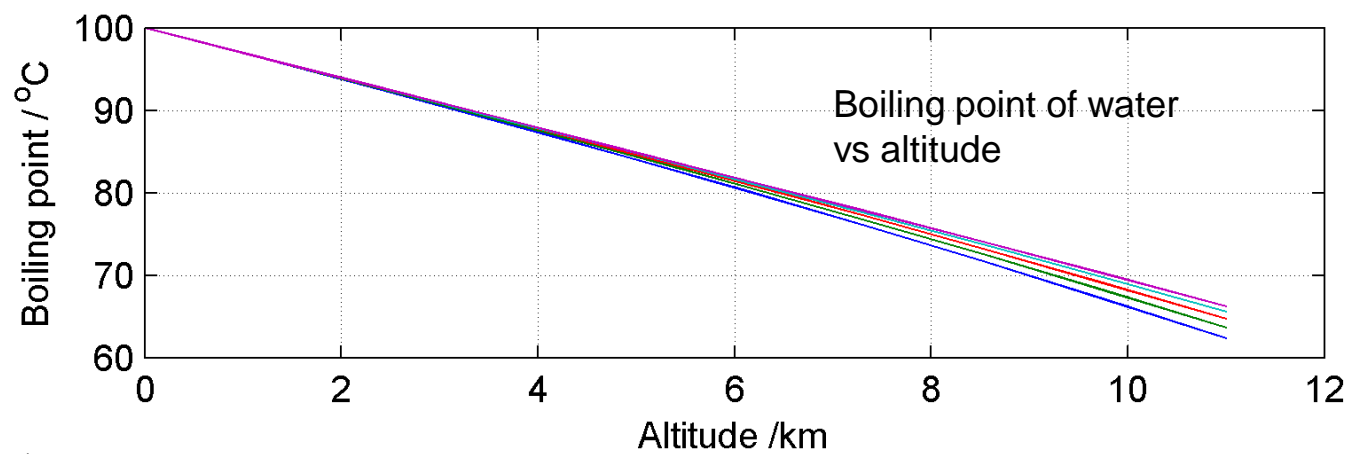
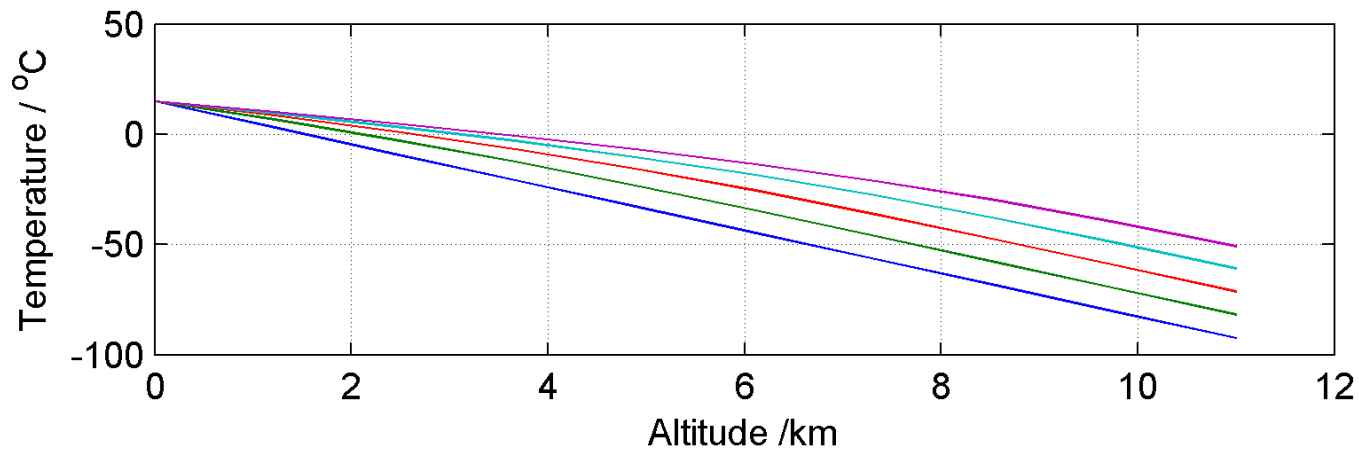




Note in the *thermosphere* the temperature (i.e. mean kinetic energy of air molecules) can rise to *several thousand degrees Celsius*. However, the air density is *extremely low*, which means it would still feel very cold indeed, as very little heat could be extracted from a given volume of air.

Lapse rates for different relative humidities





Why clouds form

Clouds contain saturated air, i.e. where liquid water has condensed out of its vapour phase. So how is this buoyant? Surely the density must exceed the air around it?

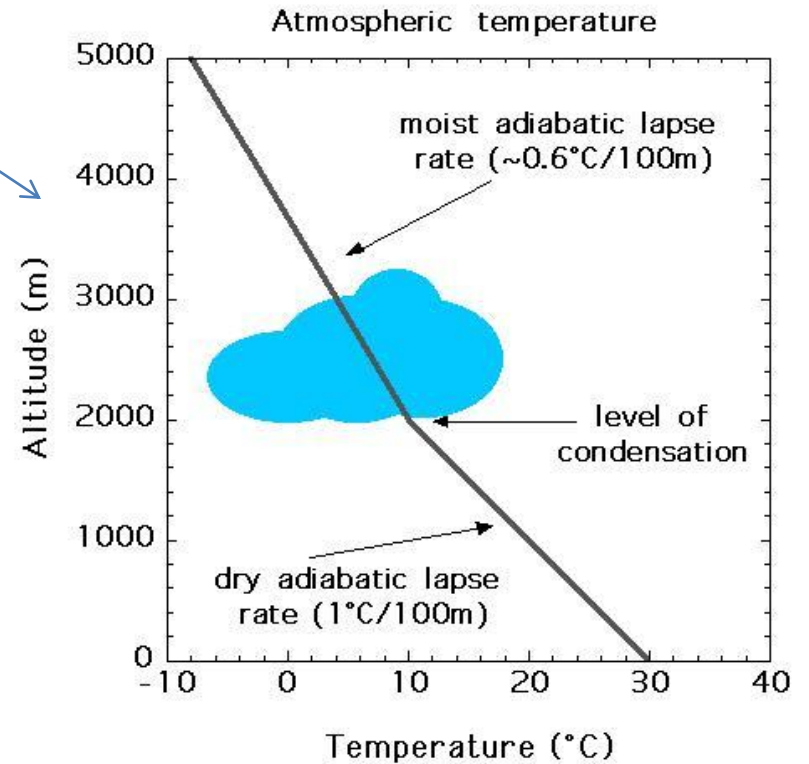
The explanation is that the air within a cloud is, on average, *warmer* than the air outside it.

This is because energy is liberated during the phase transition from vapour to liquid. A cloud therefore *contains dry air* that is *less dense* than the surrounding air. This warmer air acts as a sort of 'floatation device' for the condensed water within the cloud.

The cloud top is when the overall density inside the cloud equals to the (dry air) density outside. The cloud base is when the local air temperature reaches the dew point and condensation occurs.

One can model temperatures changes by considering a *moist lapse rate for the cloud* and a *dry lapse rate for the surrounding air*.

adiabatic
means "no heat
transfer"



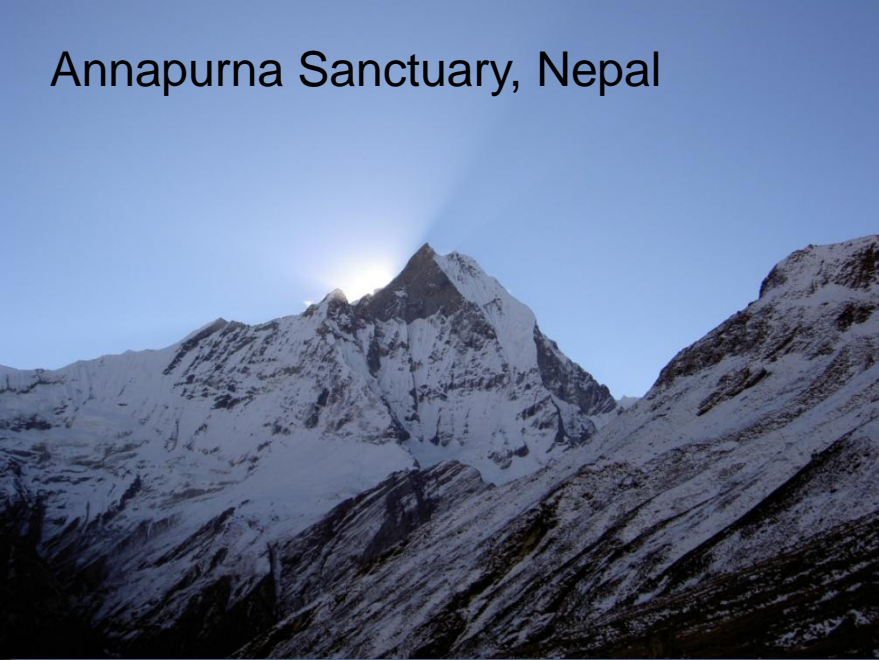
A high-altitude mountain landscape with snow-covered slopes and a climber in the foreground. The scene is dominated by bright white snow and deep blue shadows. In the foreground, a climber wearing a blue jacket and dark pants is seen from behind, standing on a snow-covered ridge. The climber is holding a long pole or ice axe. In the background, a wide, snow-covered valley opens up, with a faint trail leading up a slope. The sky is a clear, pale blue. The overall atmosphere is one of a vast, cold, and challenging environment.

So why go
mountaineering?

Kilimanjaro (5895m), Tanzania



Annapurna Sanctuary, Nepal





Ben Nevis (1345m), viewed from the West Ridge of Aonach Mor





The Mera Himal. (Summit 'Mera Peak' at 6476m).
South West face viewed from the Hinku valley, near Khare.

Tenzing-Hillary Airport
at Lukla (2860m)



Voted by *The History Channel* as the **World's Most Extreme Airport!**



Ascending the Mera glacier from the Hinku valley.
Crampon use and basic winter mountaineering skills required.

Ascending the Mera glacier to High Camp.
Behold Chomolungma,
Mother Goddess of the Universe!
(And a hairy trekker).





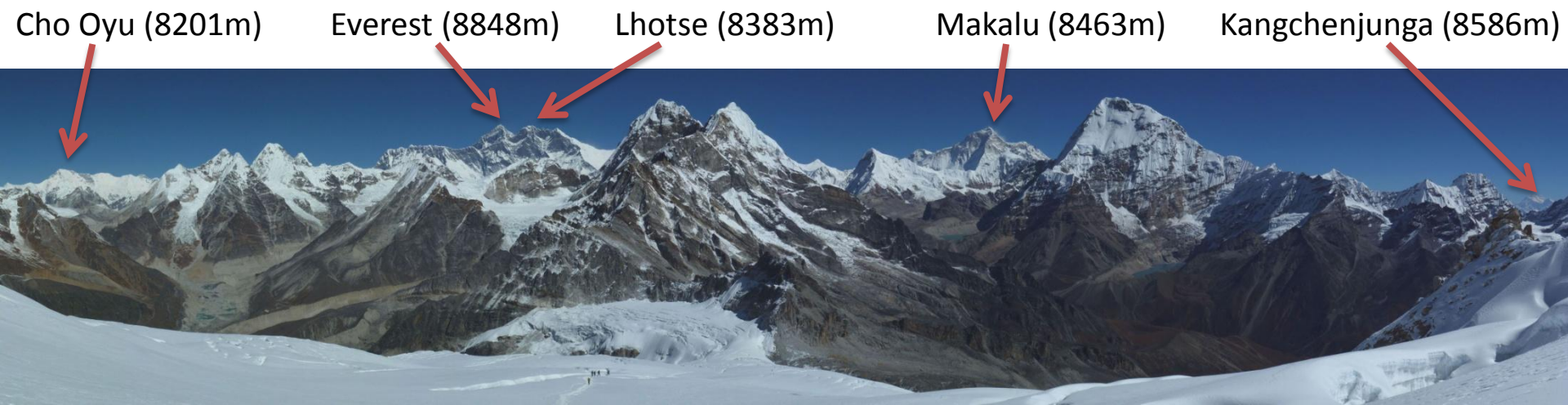
My first ice climb!



Mera summit photos by
Dave Kenyon



Five of the world's highest mountains! View from the Mera glacier



All photographs (apart from those credited to Dave Kenyon) taken using a Panasonic TZ8. Panoramic images assembled using Microsoft Research Image Composite Editor <http://research.microsoft.com/en-us/um/redmond/groups/ivm/ICE/>

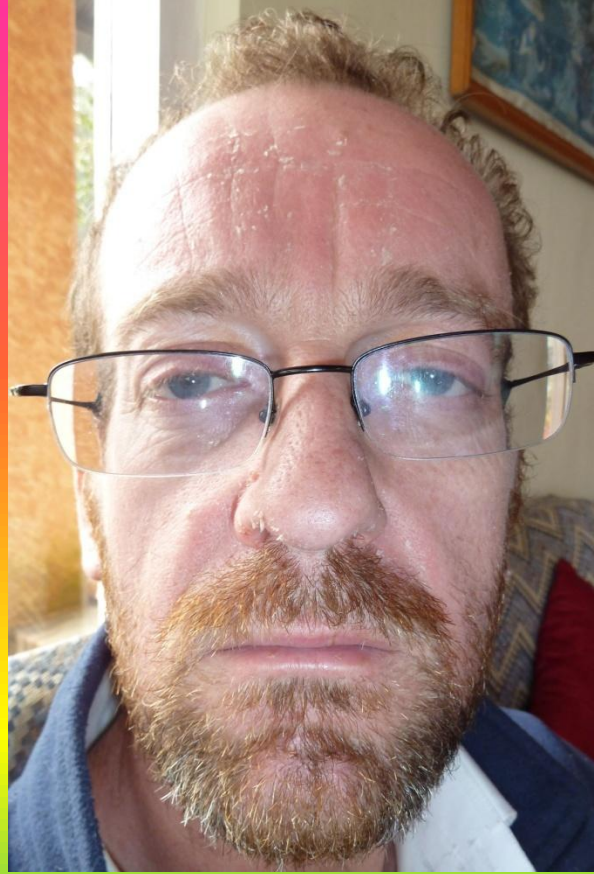
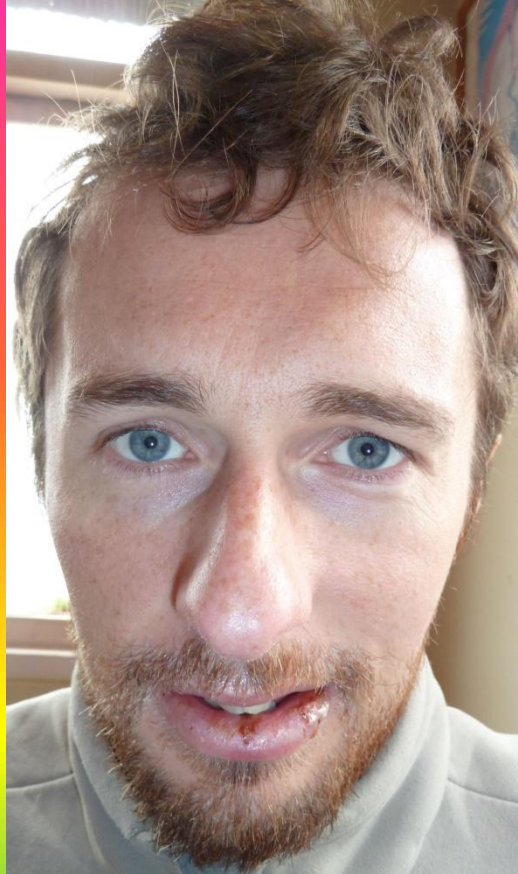


After two weeks of miracles and misery, rescue arrives from Panch Pokhari ('Five Lakes') at 5400m)



Beard-o-rama





Three weeks
later....



Chamonix to Zermatt *Haute Route*



Dramatic crevasses on the Stockji glacier under the North Face of the Matterhorn (4478m)



Bertol Hut (3311m)







Mont Blanc (4808m)
via *Cosmiques* route



On the Toubkal (4167m) summit ridge. Atlas mountains, Morocco.



Glacial lakes *Capitelli* and *Melo* on the GR20, Corsica



Glacier between Klein Matterhorn
ski station (3883m) and
Breithorn (4164m)



Summit of the Breithorn



Monte Rosa

Nordend

Dufourspitze

Zumsteinspitze

Parrotspitze

Liskamm

Pollux

Castor

Summit ridge of the Breithorn (4164m)

Monte Rosa hut (2883m) and Liskamm (4527m)



Monte Rosa hut above the Gorner glacier

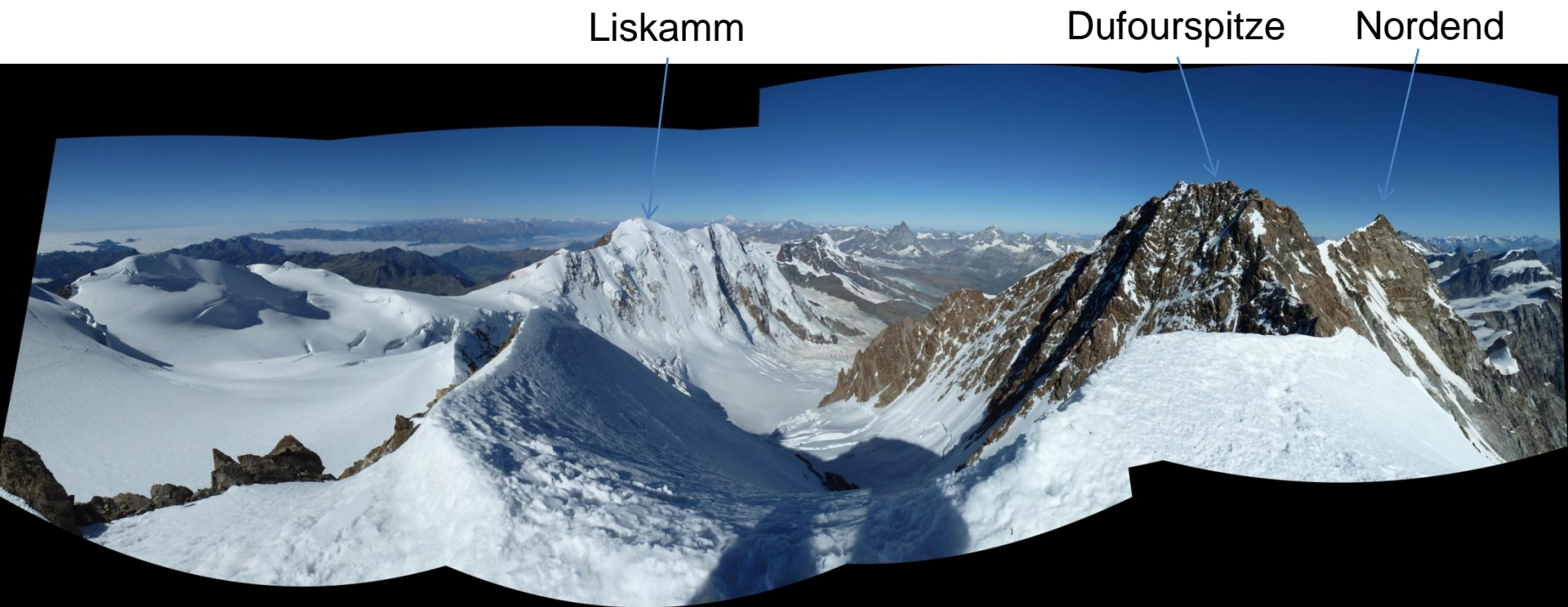




Amazing shadows as the sun sets directly beneath the peak of the Matterhorn



Gretzglecher at dawn, following a night navigation of its labyrinthine crevasse field!
Sunrise illumination of the Breithorn.



Liskamm

Dufourspitze

Nordend

Panorama from the summit of Zumsteinspitze (4563m)

Summit of Zumsteinspitze (4563m). Italy lies beneath the cloud inversion.

