



THE PERLAN PROJECT & AVIATION WEATHER

Elizabeth J. Austin, Ph.D., CCM
CEO & Founder

Intermountain West Aviation Weather Safety Workshop– June 10,
2022



PERLAN PROJECT

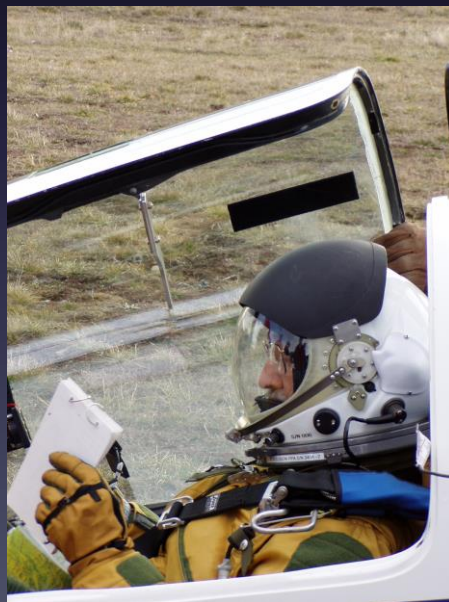
Nonprofit organization where
scientists, engineers and pilots
volunteer their time to better the
planet



Exploration | Innovation | Inspiration



The Perlan Project



Mountain PSC, Kebnekaise



Perlman or Nacreous Clouds 50,000 – 80,000 feet

Nitric acid and
water



Meteorological Conditions

- Prefrontal conditions are best
- Post frontal may be o.k. in the drier Andes (but not in New Zealand)
- Strong low-level winds in a stable atmosphere with ridge top winds 40 knots is best (25 knots will work)
- Winds within 30 degrees of perpendicular to ridgeline
- A gradual wind increase with altitude (Energy)!
- A weak tropopause will allow the wave to traverse into the stratosphere
- Region influenced by Polar vortex!

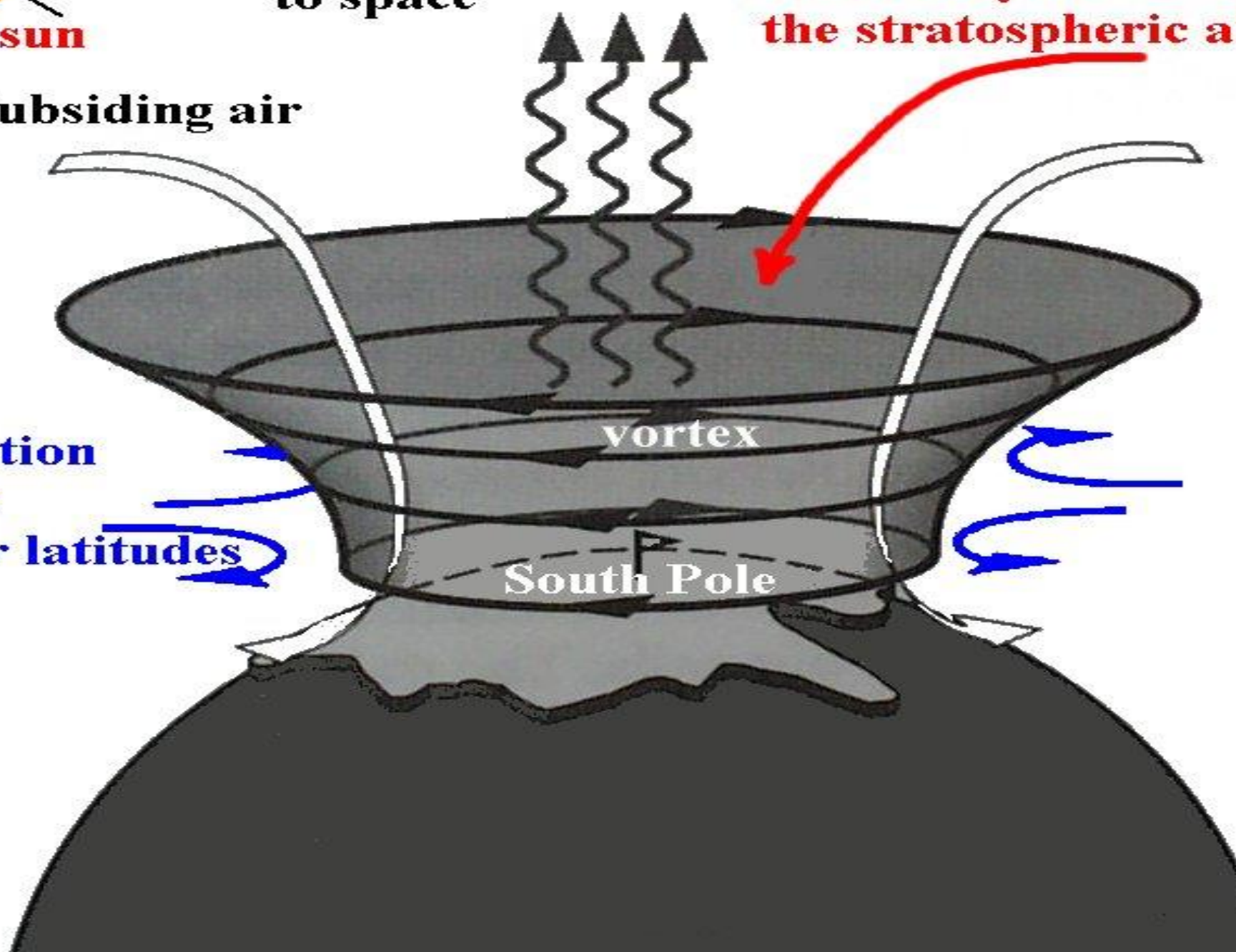


**Thermal radiation
to space**

**Chemistry of
the stratospheric a**

Subsiding air

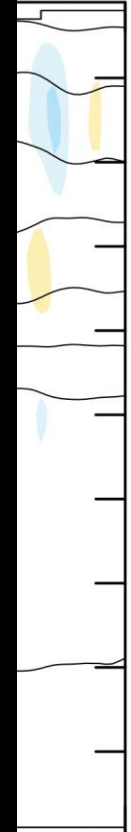
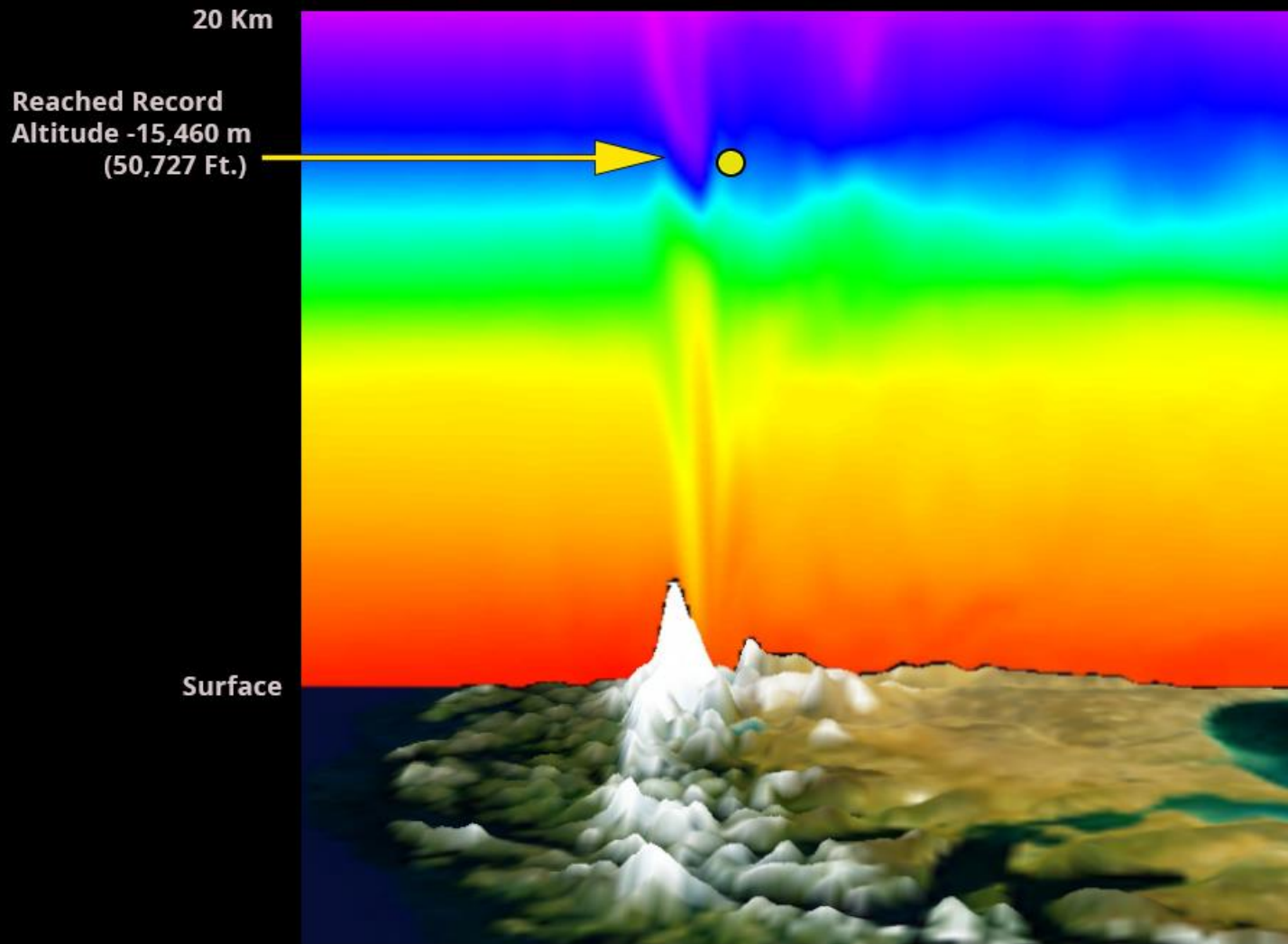
**Isolation
from
other latitudes**



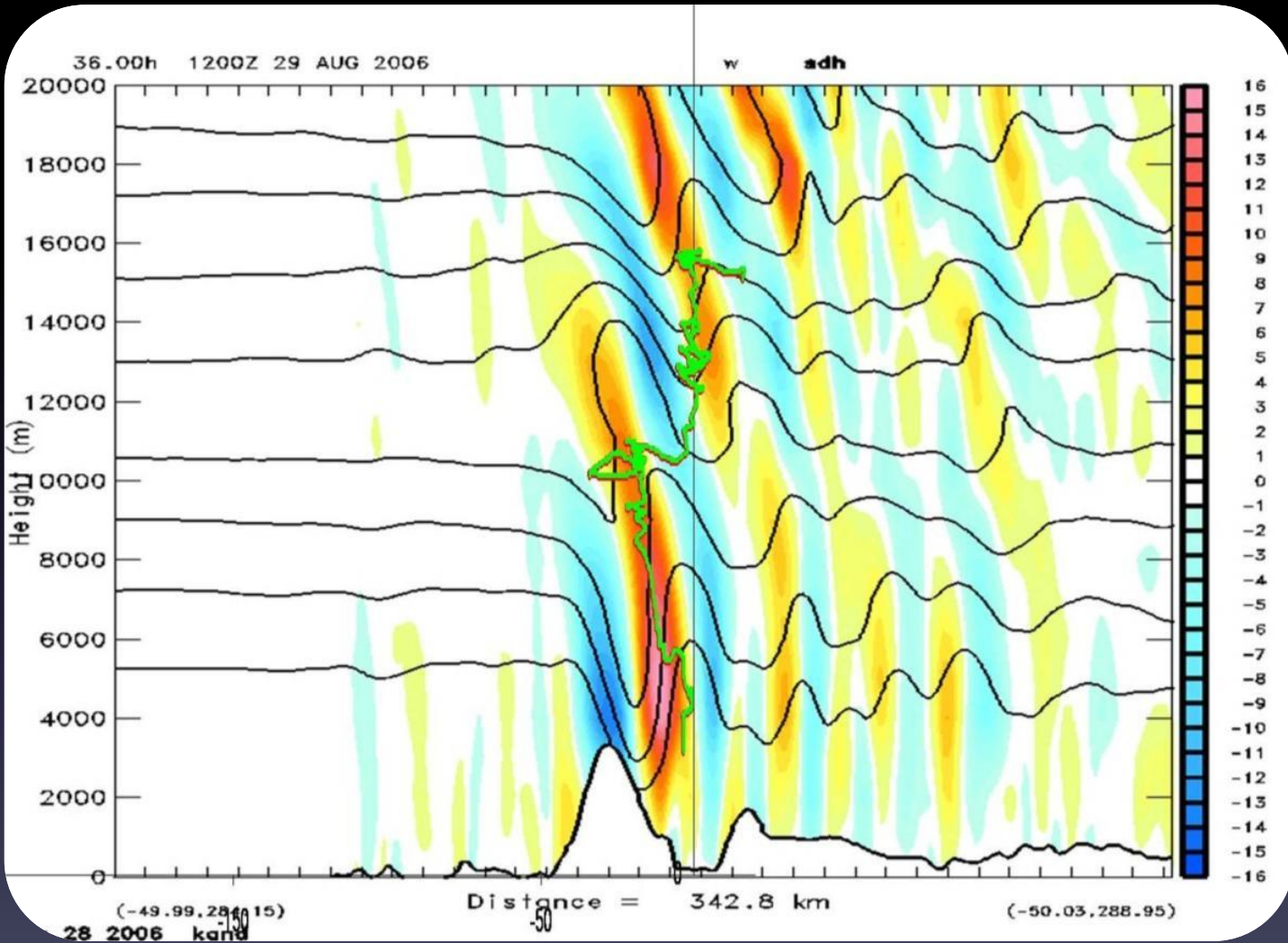


Perlan Record Flight

Air Temperature - Cross Section



Record Flight Track with Lift and Sink



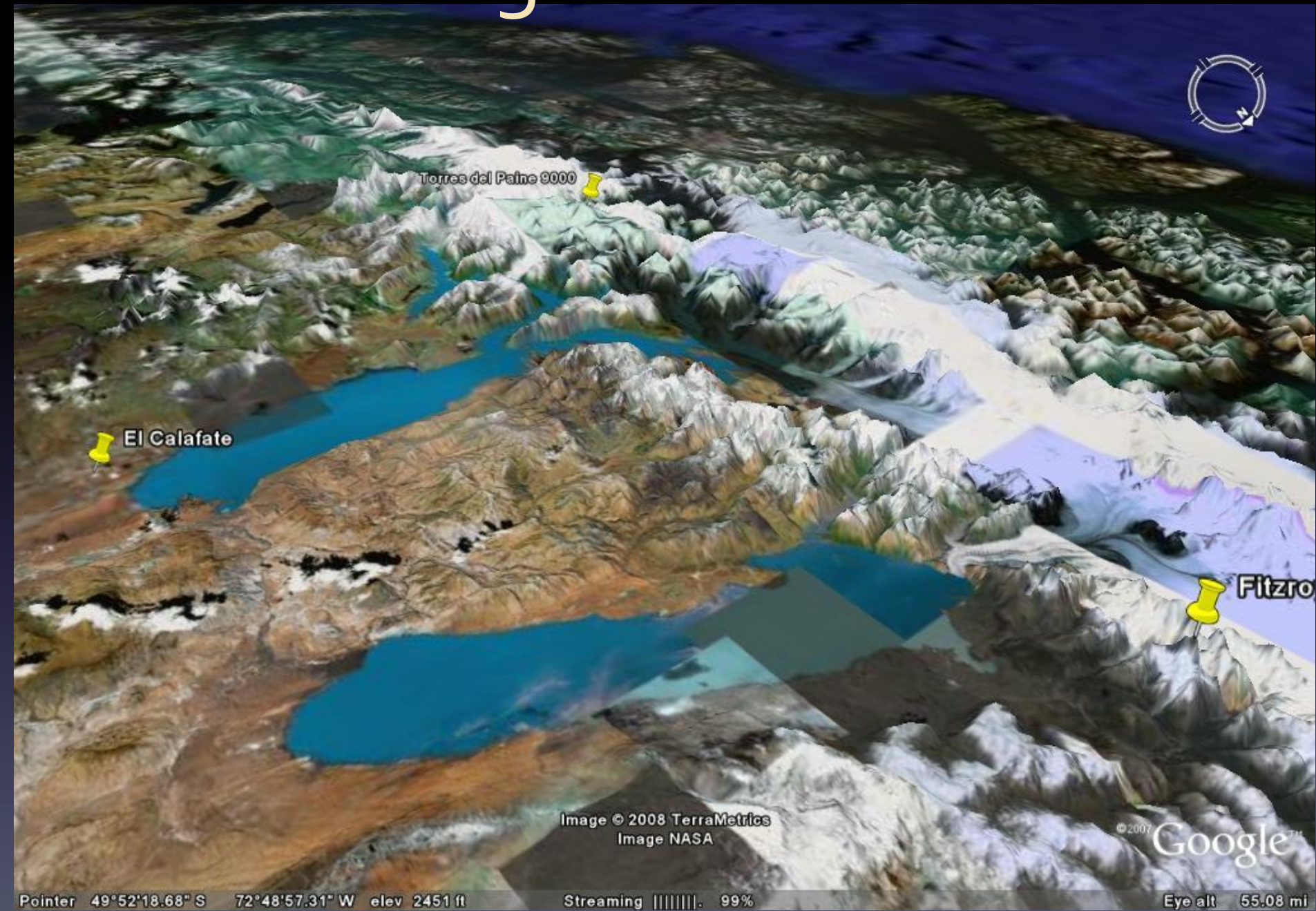


El Calafate,
Argentina



50° South Latitude

Patagonian Andes



The Egrett Tow Plane

06.24.18

FIRST EVER TOW WITH EGRETT



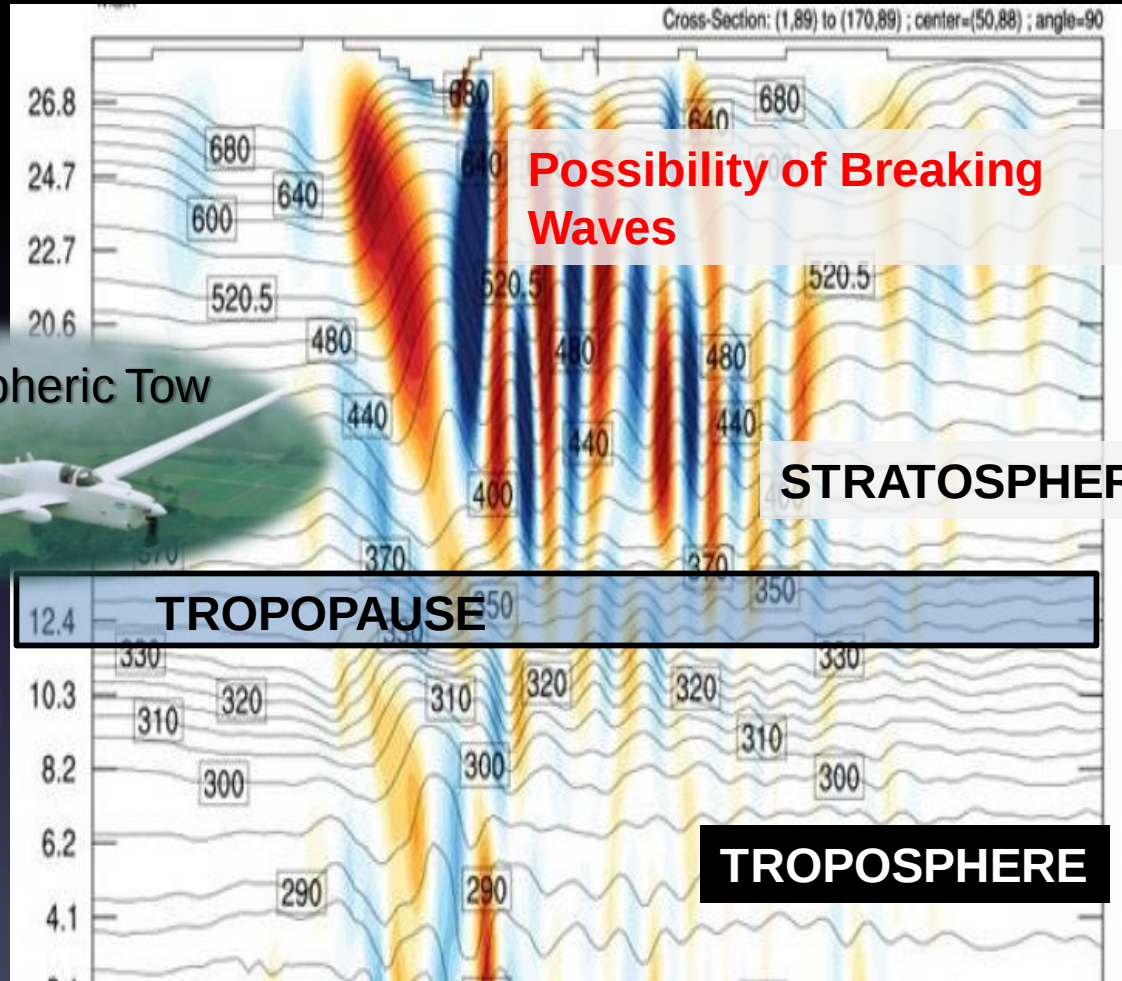
In 2018 & 2019 we will tow directly into the highest waves

KM

of record
flights by
50%

Stratospheric Tow

PERLAN
PROJECT



Airbus Perlan Mission II

Record-Breaking Flight

September 2, 2018

76,124 feet



U2	72,000 feet
SR71	85,069 feet

Environmental Control and Life Support

- AIR in the CABIN



21% O₂ from Scuba Tank

De-Humidified Air

PILOT OXYGEN



Rebreather: 90-99% O₂

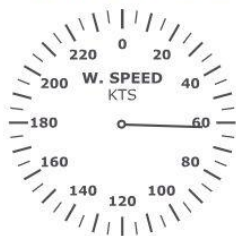
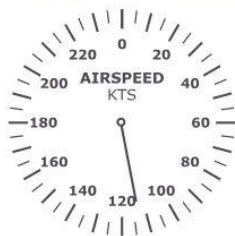
Humid re-circulated

GLIDER ALTITUDE: 34492 ft

VERTICAL SPEED: 0 kts

GLIDER SPEED:

WIND SPEED:



GLIDER HEADING:

289°

WIND DIRECTION:

267°

48%

AIR TANK

76%

O2 TANK

48%

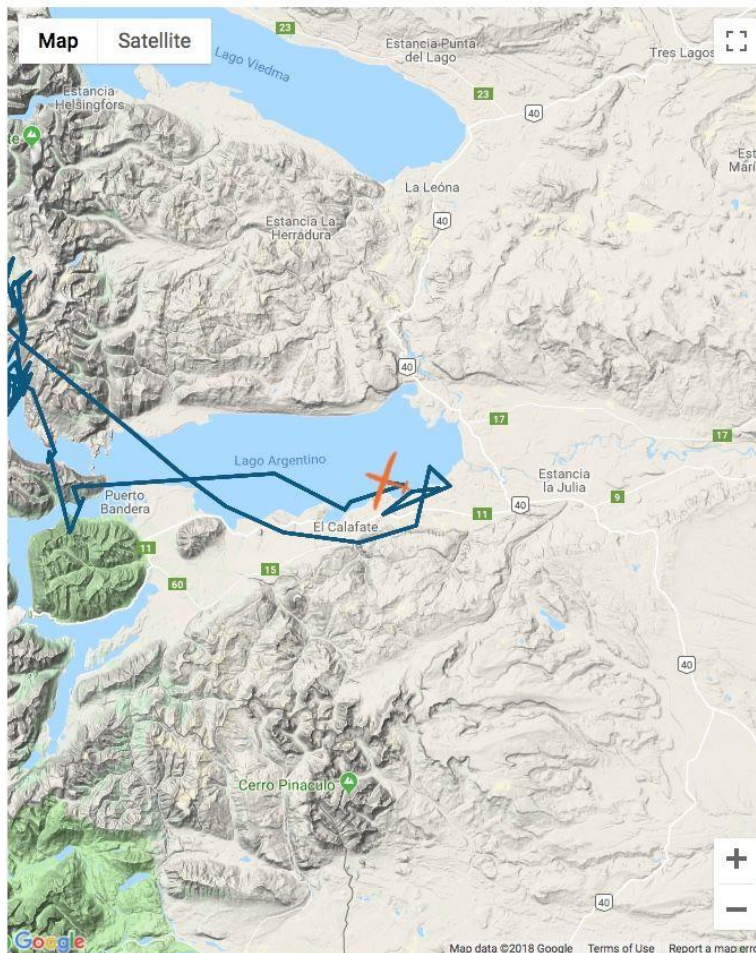
BATTERY

MAX ALTITUDE:

62473 ft

FLIGHT TIME:

04:44:06



Tweets by @PerlanProject



Perlan Project

@PerlanProject

Get future notifications when the Perlan 2 Virtual Cockpit is live.

Sign up for email at perlanproject.org/contact

OR

Get text message alerts in the U.S. by texting "Perlan" to 57682#AirbusPerlanMission II



12m



Perlan Project

@PerlanProject

Update: After finding a bit more lift, the Perlan 2 #glider and its pilots Jim Payne and Morgan Sandercock are heading back to the airport in El Calafate. We'll do some #weather model testing on the downwind. #AirbusPerlanMission II

Follow our descent

>perlanproject.cloud/VirtualCockpit...



16m



Perlan Project

@PerlanProject

Update: The Perlan 2 glider has topped out in this last pocket of lift. One more pocket to try.

Embed

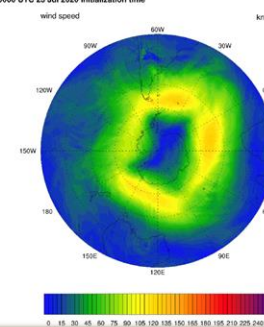
View on Twitter

Briefings & Wx Forecasting

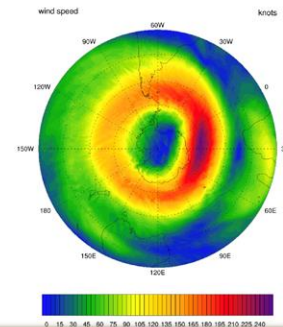


GFS polar jet depiction at 70 hPa and 10 hPa for July 24, 2020 0000 UTC initialized July 23, 2020 0000 UTC

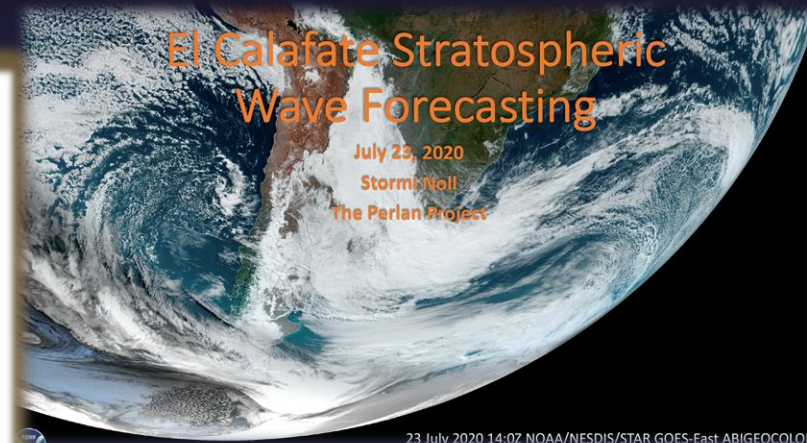
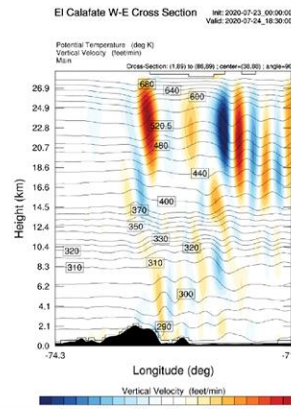
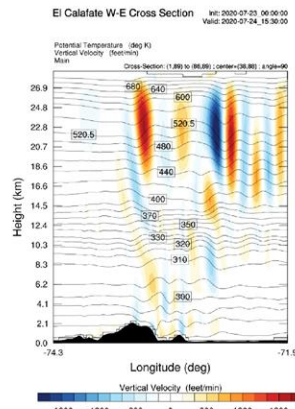
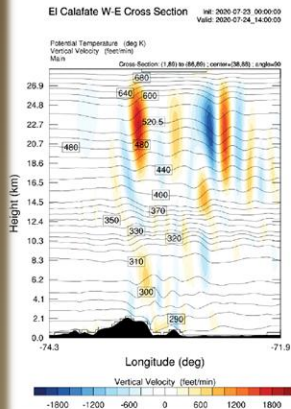
70 hPa Wind speed (knots) for 0000 UTC 24 Jul 2020
0000 UTC 23 Jul 2020 initialization time



10 hPa Wind speed (knots) for 0000 UTC 24 Jul 2020
0000 UTC 23 Jul 2020 initialization time



WeatherExtreme experimental WRF El Calafate cross-sections for July 24, 2020 (14:00, 15:30, and 18:30 UTC) initialized July 23, 2020 0000UTC



23 July 2020 14:0Z NOAA/NESDIS/STAR GOES-East ABIGECOLOR

The Perlan Glider



Crew: 2

Gross Weight: 2000 lbs

Aspect Ratio: 27

Cabin Pressure: 8.5 PSID

Wing Span: 84 feet

Empty Weight: 1544 lbs

Wing Area: 263 sq ft

Core Atmospheric Scientific Packages on Perlan II

- **Cameras on Glider**
- **Ozone**
- **Ultra Violet (UVA/UVB)**
- **Pressure**
- **Air Temperature**
- **Electromagnetic Radiation (measures pilot exposure)**
- **Water vapor (calculated Year 1, measured Year 2-Picarro)**
- **Relative Humidity (measured) and Dew Point Temperature (calculated)**
- **Winds – horizontal and vertical**
- **Radio Occultation (water vapor)**



FUTURE

- **Atmospheric aerosol measurement (LIDAR on Egrett)**
- **Methane (Picarro-Year 2)**
- **Isotopic CO2 (Picarro-Year 2)**
- **Carbon Monoxide (Picarro-Year 2)**

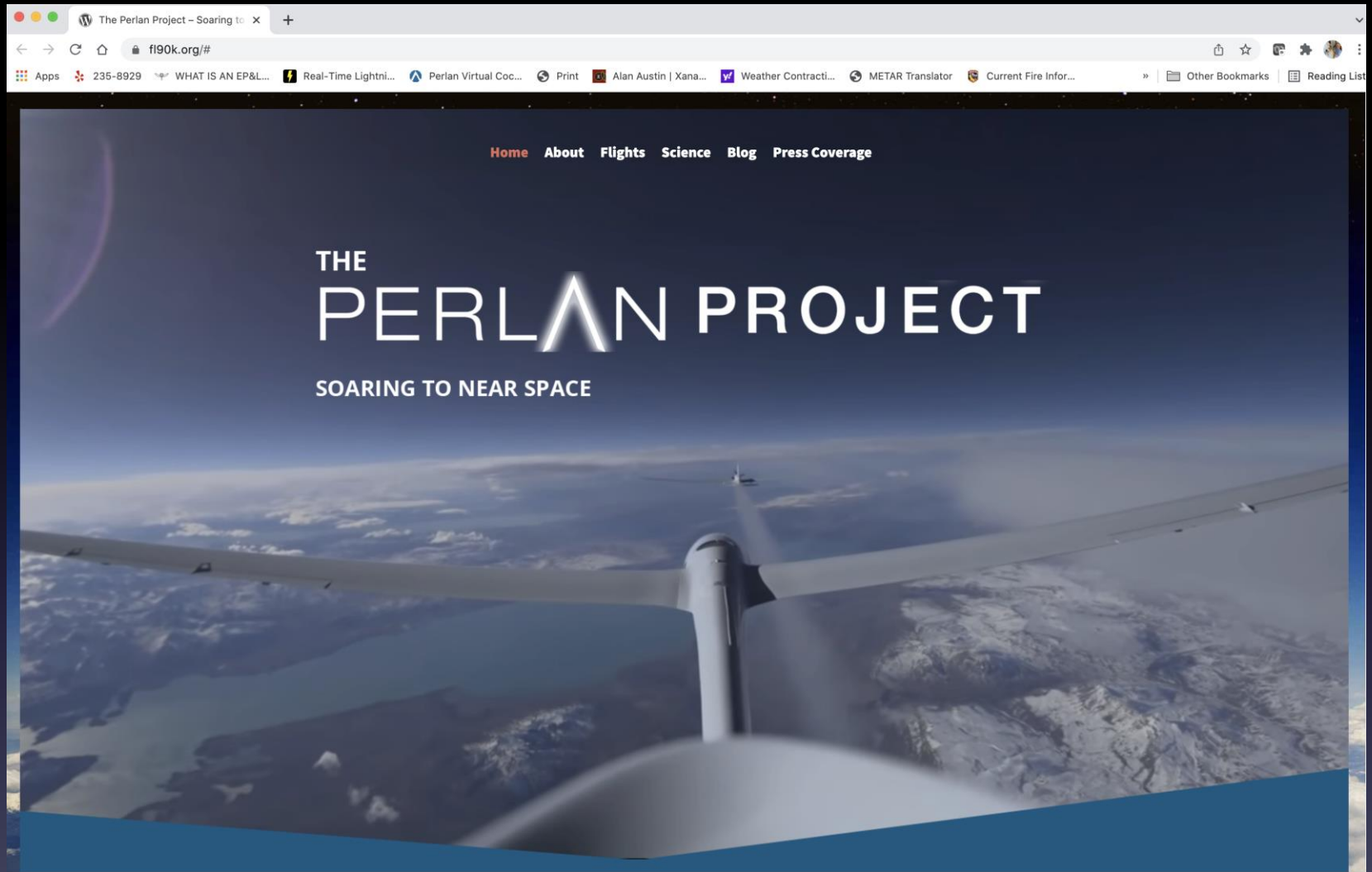
Atmospheric Scientific Packages

Ground/Space - Based Years 1 & 2



- **Time Lapse Camera(s)**
- **Soundings in Sierra & Argentina (GPS Ozone sondes in Argentina)**
- **LIDAR (array in Argentina- Dr. Jacobo Salvador Dir. Observatory of Southern Patagonia, Rio Gallegos, Argentina)**
- **NASA AIRS (Dr. Dong Wu- NASA Goddard)**
- **Satellite Imagery/Data (polar orbiting and GOES)**
- **Surface Weather Observations**

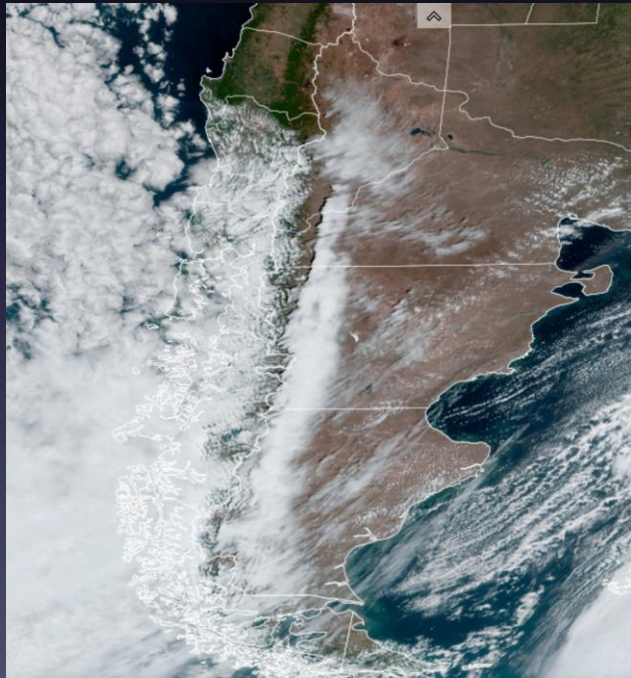
Perlan Data Archive



FL90k.org

Live Web Cams





Live Web Cams

THALES

Building a future we can all trust

Internet Communications at the edge of space

Thales is teaming with Airbus Perlan Mission II to link scientists around the world with cutting-edge climate research live from the stratosphere.

Perlan 2 Research Glider
– up to 90K ft/27 km



Egrett Research & Tow Aircraft
– 51K ft/16 km



**Iridium
Satellite**

AIRBUS
PERLAN
MISSION II

iridium®
connected

**Research scientists
around the world**



WX
WEATHER EXTREME

AI Wave Field Flight Path Optimization for Safety and Efficiency



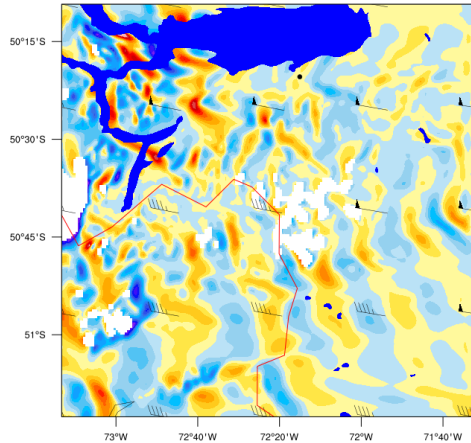
AI Wave Field Flight Path Optimization for Safety and Efficiency

Wave Structure for Sept. 3, 2017, World Record Flight

850 mb Height

Init: 2017-09-03_12:00:00
Valid: 2017-09-03_18:30:00

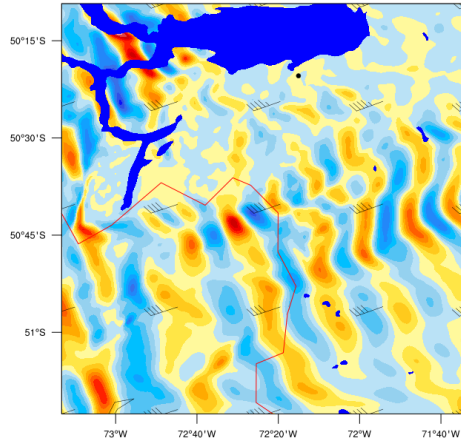
Vertical Velocity (feet/min) at 850 hPa
Wind (kts) at 850 hPa



700 mb Height

Init: 2017-09-03_12:00:00
Valid: 2017-09-03_18:40:00

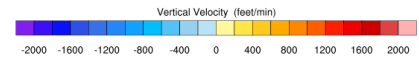
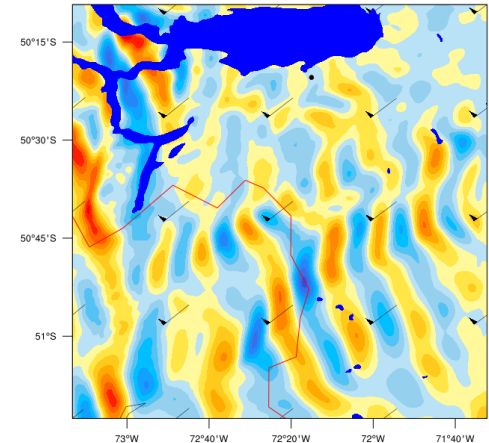
Vertical Velocity (feet/min) at 700 hPa
Wind (kts) at 700 hPa



500 mb Height

Init: 2017-09-03_12:00:00
Valid: 2017-09-03_18:40:00

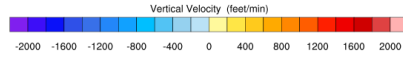
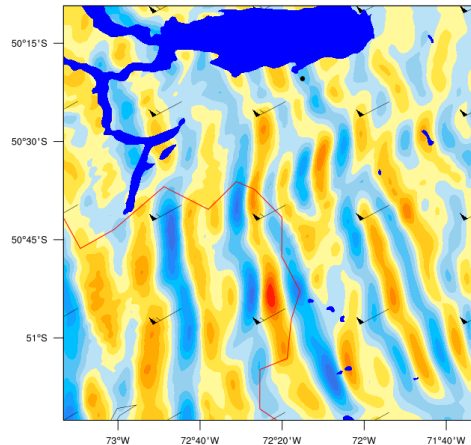
Vertical Velocity (feet/min) at 500 hPa
Wind (kts) at 500 hPa



300 mb Height

Init: 2017-09-03_12:00:00
Valid: 2017-09-03_18:40:00

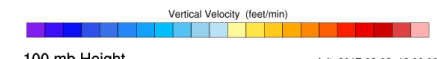
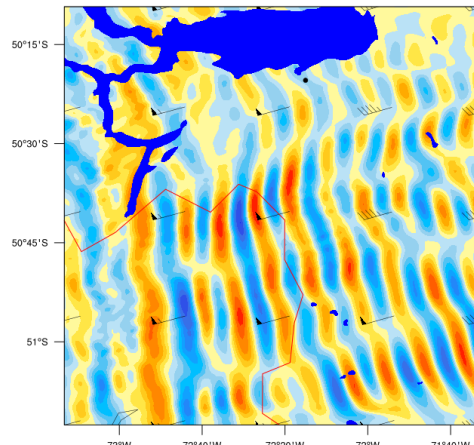
Vertical Velocity (feet/min) at 300 hPa
Wind (kts) at 300 hPa



200 mb Height

Init: 2017-09-03_12:00:00
Valid: 2017-09-03_18:40:00

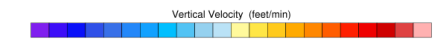
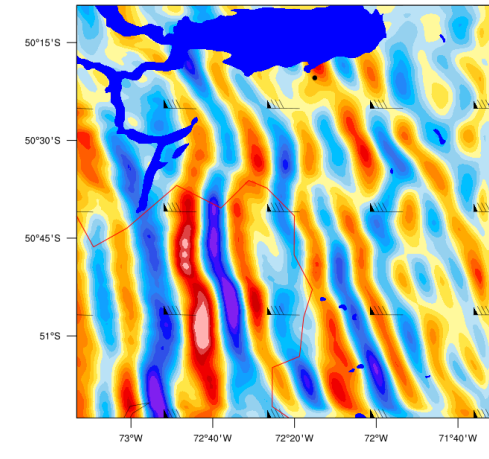
Vertical Velocity (feet/min) at 200 hPa
Wind (kts) at 200 hPa



100 mb Height

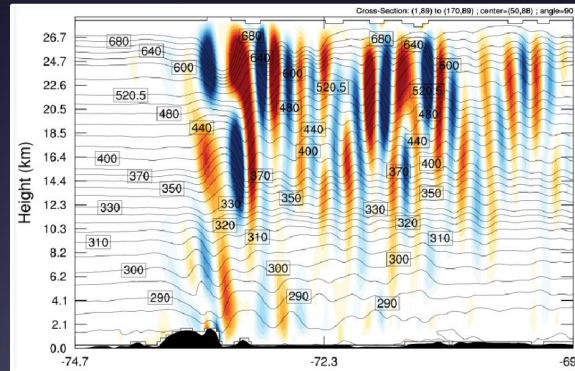
Init: 2017-09-03_12:00:00
Valid: 2017-09-03_18:40:00

Vertical Velocity (feet/min) at 100 hPa
Wind (kts) at 100 hPa



Aviation safety

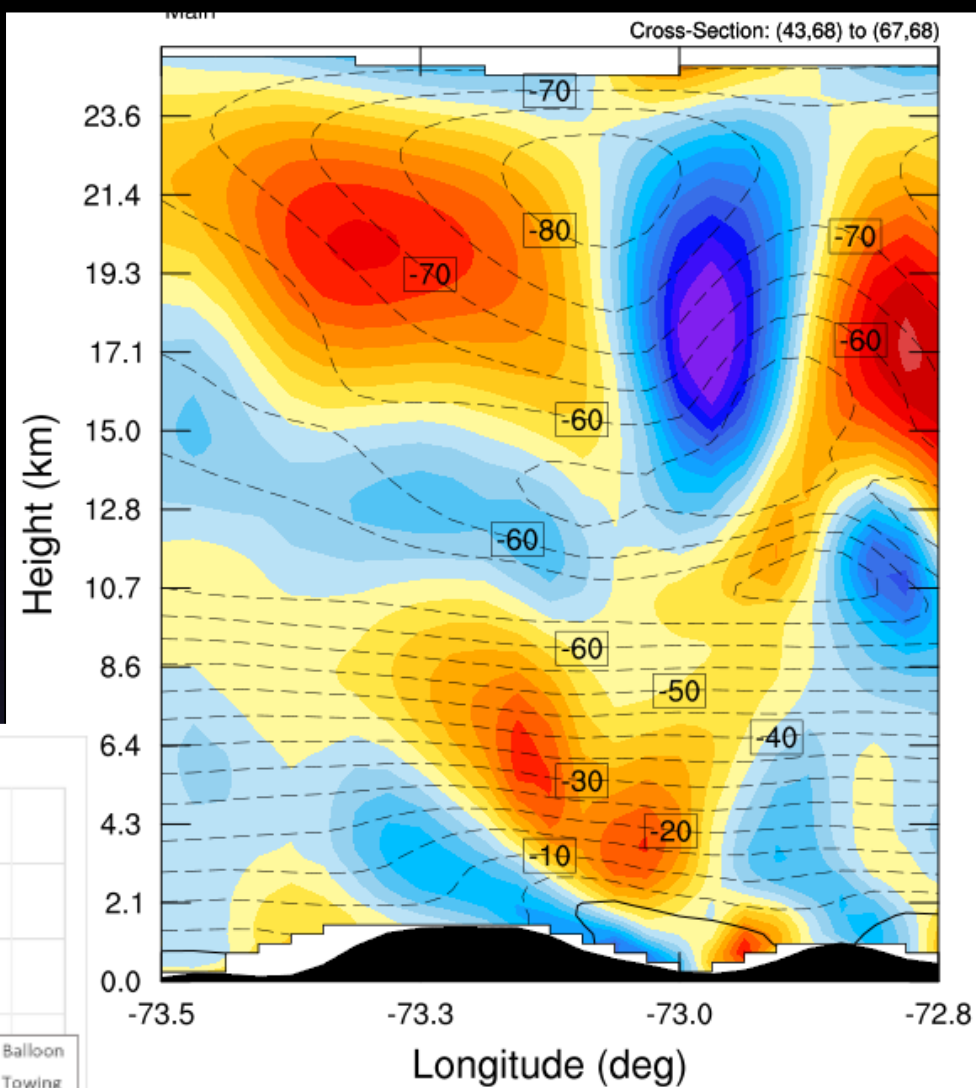
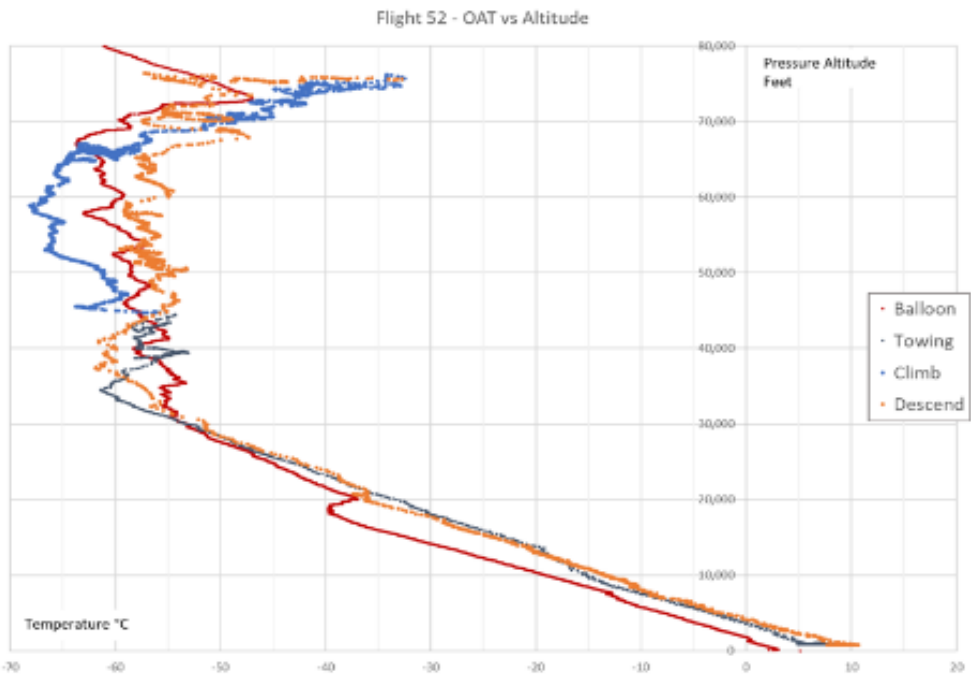
Encountering invisible mountain waves can be a serious risk to aircraft and passengers



Cockpit displays of these invisible waves plus speed and flight path suggestions would help protect aircraft and passengers

Science Data Collection

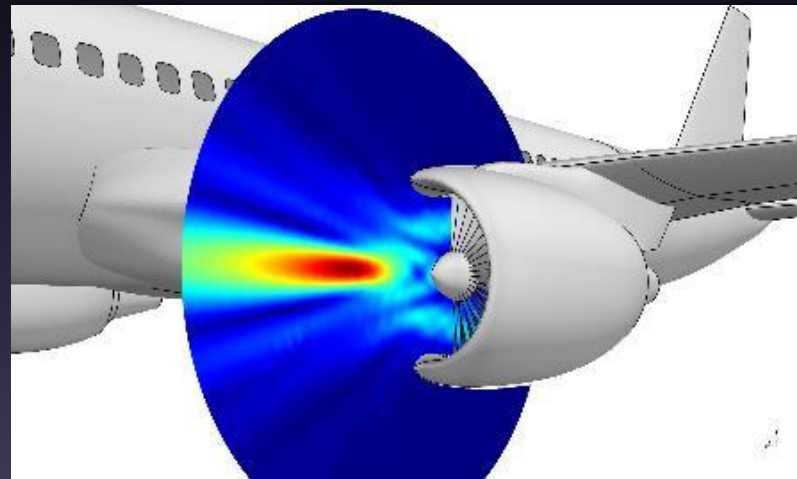
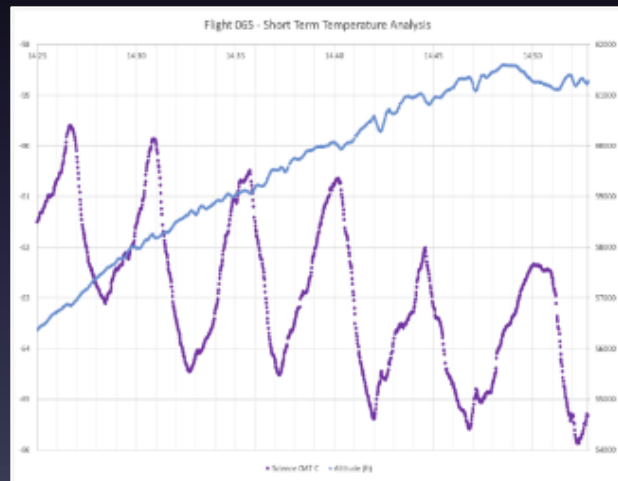
- Wave location & strength
- Temperatures
- Radiation
- Ozone
- Particle / dust collection
- “CubeSats”



- Large horizontal temperature gradients in the waves

Predict wave field temperature excursions

- Wave fields are known to have large horizontal temperature excursions
- AI may help engine inlet controllers adjust to these rapid temperature variations during passage through wave fields



Riding waves: Provide a dramatic demonstration of the energy in atmospheric waves.

Altitude records broken using only wave power!



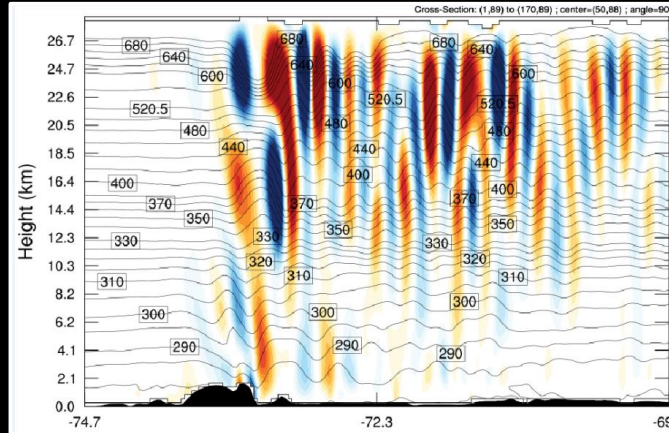
U-2



Concorde



Commercial airliners



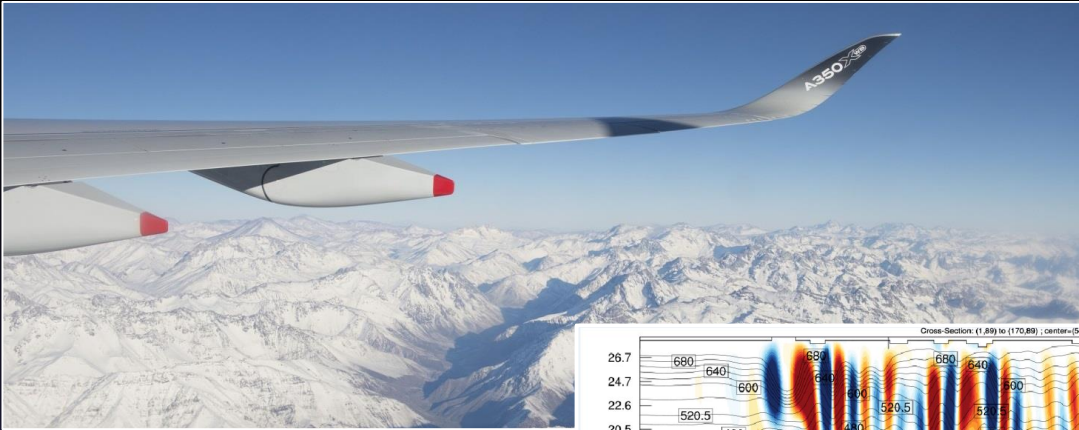
Next, the SR-71



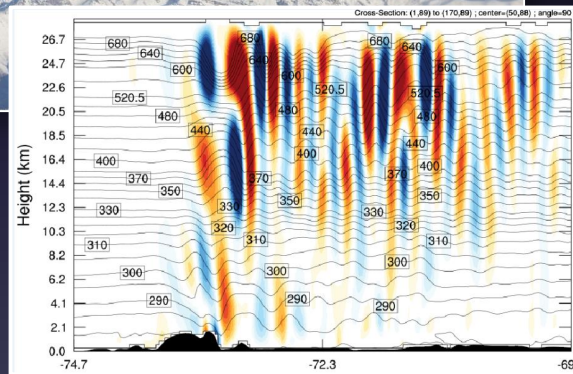
Perlan's goal, 90,000 feet



More sustainable aerospace by reducing fuel consumption.



AI flight path
optimization could
guide aircraft into the
lift zones.

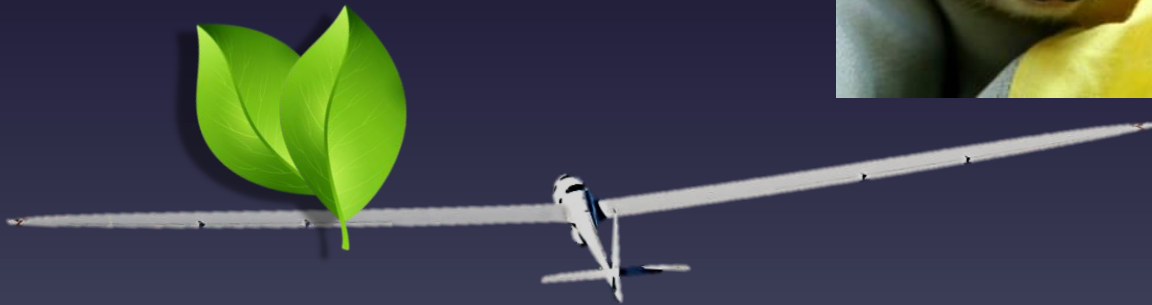


If pilots could
see atmospheric
waves,
there will be times
they could “ride” them
to save fuel.

An airliner flying in
rising air could save
up to 90 lbs. of fuel
per minute.

Exploration: Destructive environmental events that start in the stratosphere

2019 sudden stratospheric warming
in the southern hemisphere
altered weather patterns
that contributed to an early and
severe fire season in Australia



Of more sustainable and safer flight.

Inspirational news coverage in 60 countries



Fourteen prestigious awards and world records.



AVIATION WEEK /





PARTners is a consortium of scientists, meteorologists, and aviators dedicated to unlocking the most intriguing mysteries of the atmosphere.

- 1. Volcanic Ash Plume Characterization for the Airline Industry**
- 2. Sonic signatures for atmospheric turbulence and stratospheric breaking waves**
- 3. Extremely lightweight drop sondes for extreme weather analysis**
- 4. Remote sensing of atmospheric chemistry**
- 5. Stratospheric water vapor**





THANK YOU!

In memory of

Steve Fossett
(1944 – 2007)



Einar Enevoldson
(1932 – 2021)



Doug Perrenod
(1947 – 2022)



Preston Michie
(1949 – 2022)



WeatherExtreme.com
PerlanProject.org

elizabeth@weatherextreme.com