WPC South American Desk Presentation

Forecasting Turbulence in the Austral FIR and Wind Gusts in SCCI:

15-16 June 2015 Case Study

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24 July 2015

Forecasting Turbulence in the Austral FIR and Wind Gusts in SCCI: June 15-16 2015 Case Study.

MOTIVATION

- An important problem in aeronautic meteorology is to forecast turbulence at any level.
- Turbulence affects aircrafts and passengers.
- It is not a constant/continuous process and is hard to detect/document.

CASE STUDY

- Deep tropospheric turbulence event that coincided with a strong wind gust event at SCCI (Punta Arenas Airport).

OBJECTIVES

- Identify meteorological patterns and processes that contribute to the analysis and forecasting of turbulence and wind gusts.
- Test suggested methods for determining the potential for turbulence and wind gusts.

DATA AND TOOLS

Study Period: June 15-16 2015

Location: Extreme Southern Chile (Magallanes Region)

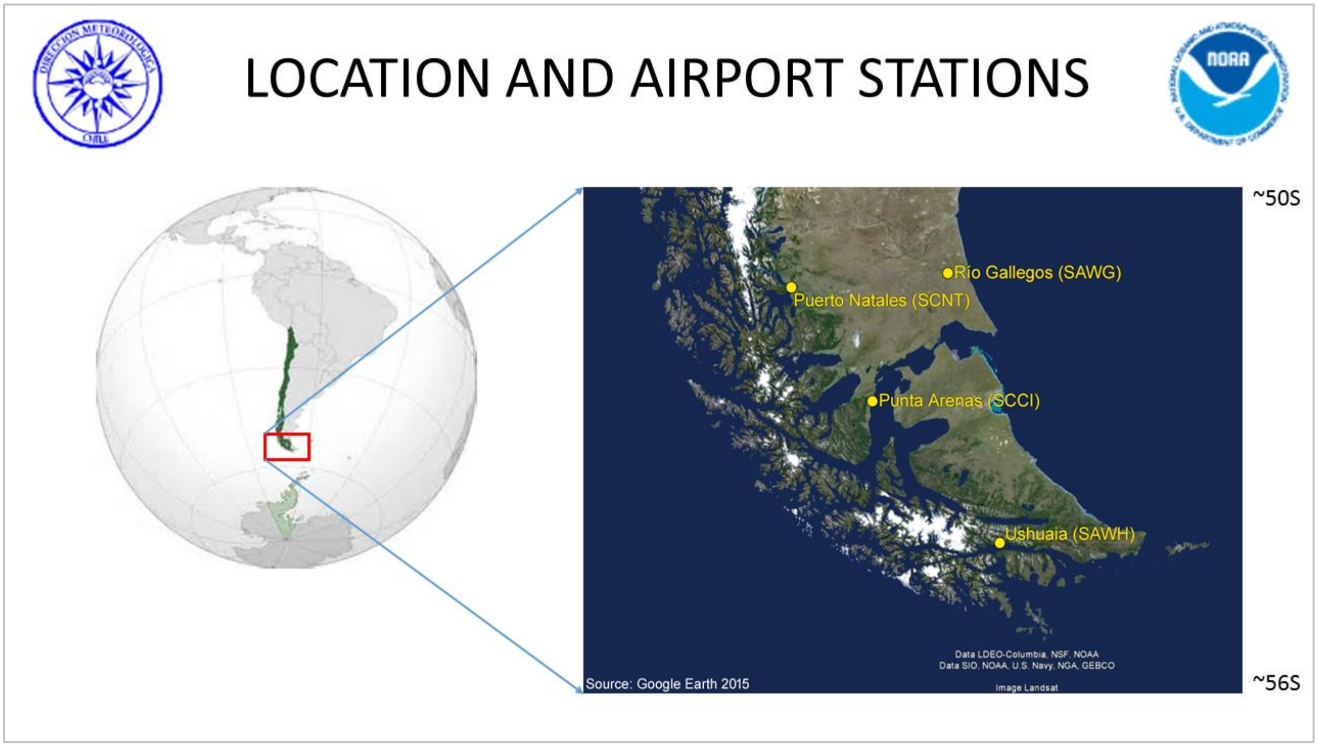
Ground Stations: Puerto Natales (SCNT), Punta Arenas (SCCI), Ushuaia (SAWH), Rio Gallegos (SAWG), Puerto Williams (SCGZ)

DATA:

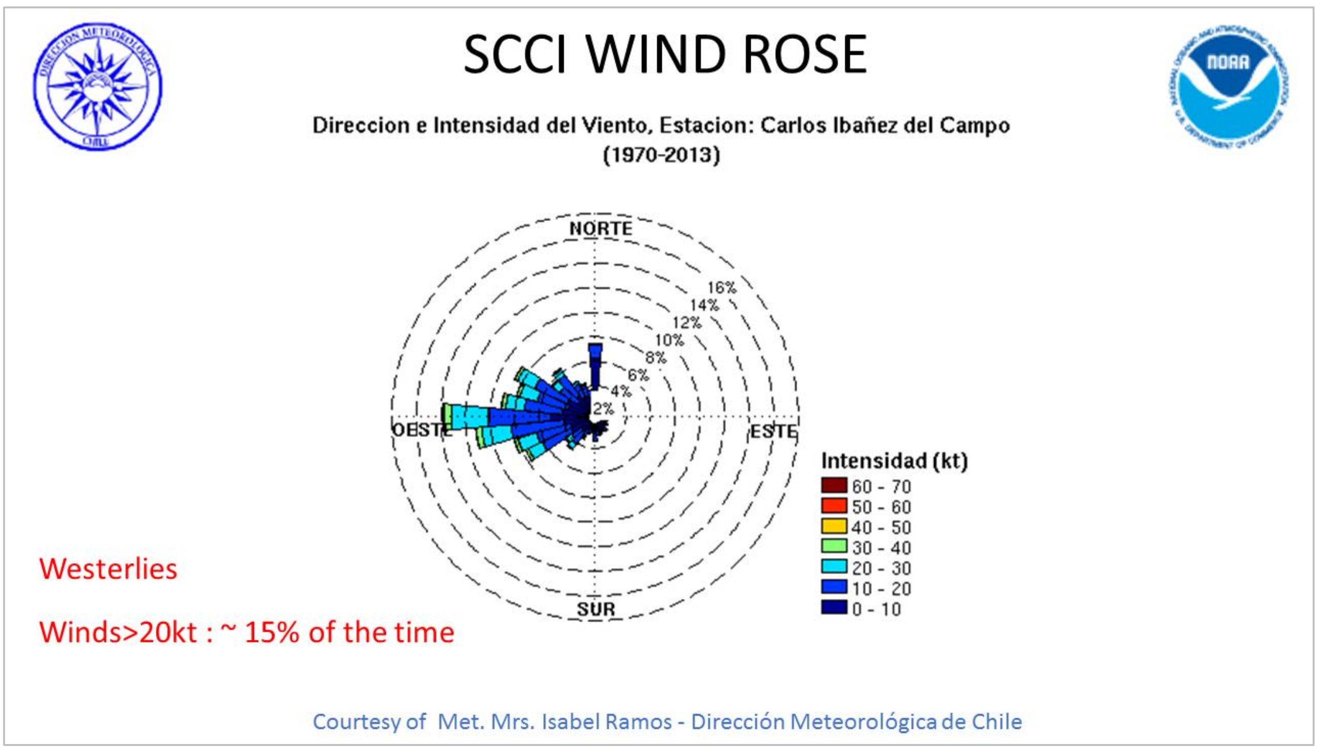
- ✓ Satellite Imagery
- ✓ METARs
- ✓ Soundings (U. Wyoming)
- ✓ GFS 1° data
- ✓ WAFC Washington Turbulence Charts
- ✓ South American Desk Analysis and Forecast Charts

ANALYSIS TOOLS:

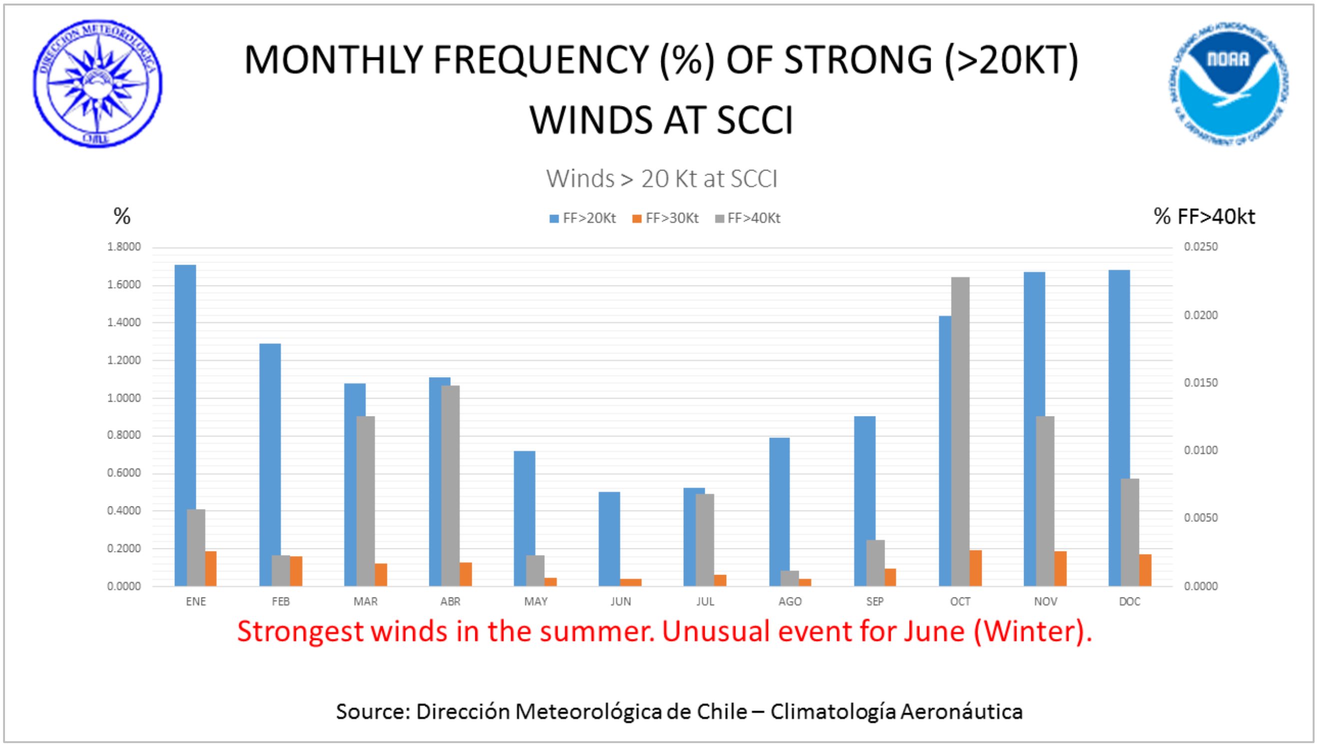
- ➢ Wingridds
- ➢ NAWIPS



Chile’s Austral fir is located in the southern tip of South America.



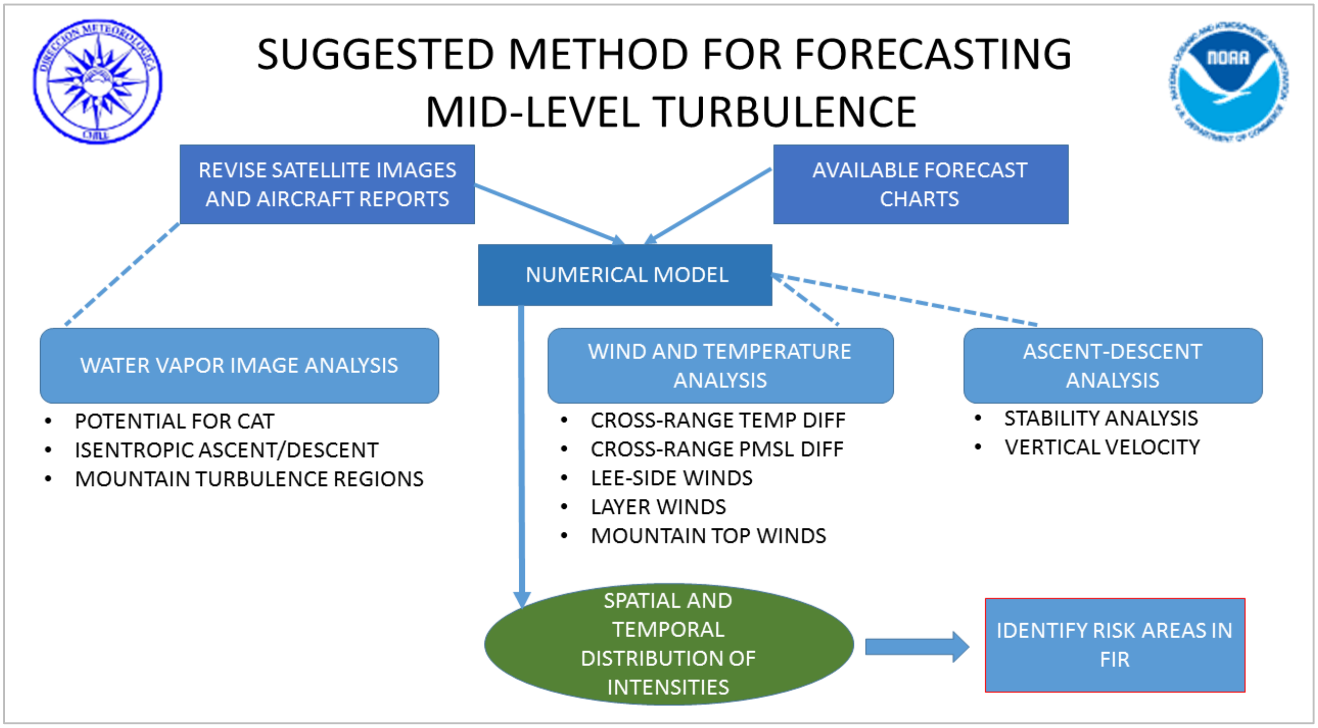
The wind rose in SCCI (Punta Arenas) shows that the prevailing wind direction is westerly. Winds are often from the western quadrant.



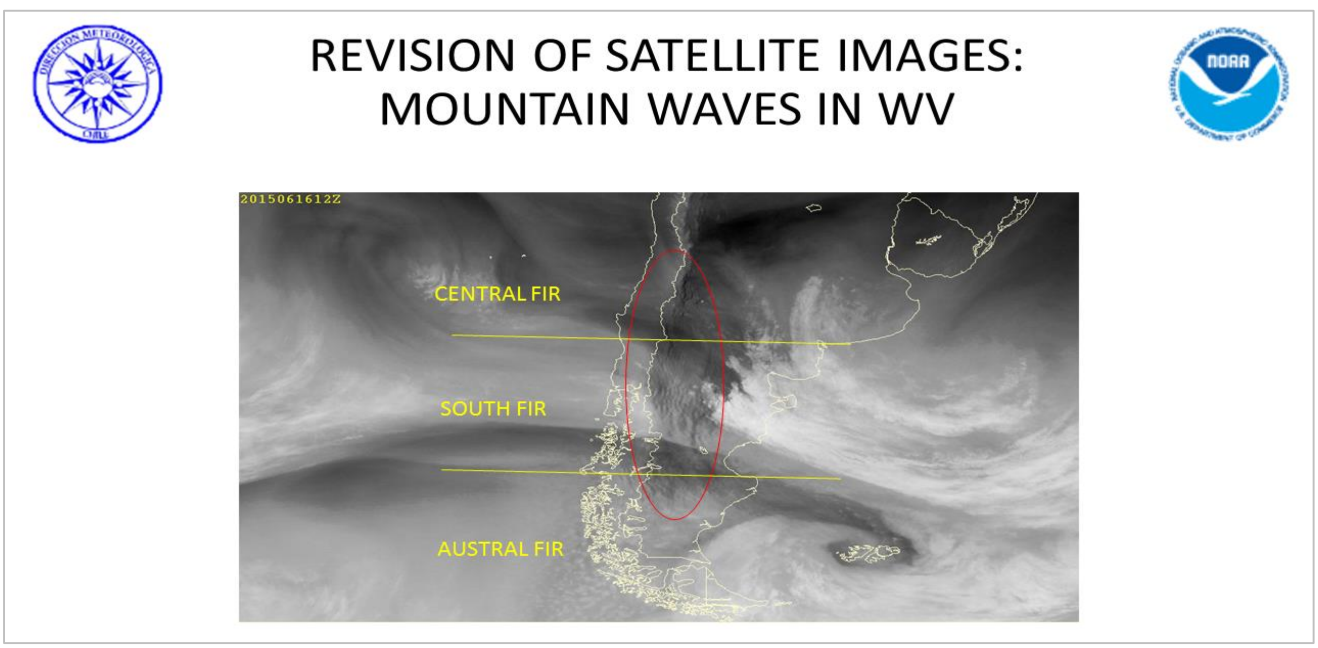
The monthly frequency of winds stronger than 20kt is presented. The graphic shows that the highest frequencies of strong winds during the spring and summer, when the belt of strong westerlies retreats to the south into the latitudes of Punta Arenas. The lowest frequencies of strong winds occur during winter. Frequencies of winds greater than 40kt are also near a minimum in June. The 15-16 June 2015 event was unusual.

MID-LEVEL TURBULENCE

Consideration of Mountain Wave Effects



A method to forecast mid-level turbulence is proposed. It consists of revising satellite images and aircraft reports, and available forecast charts to then use numerical model output to issue a turbulence forecast. The forecast includes spatial and temporal distribution of turbulence intensities, which allow the identification of risk areas.



The water vapor image is first used to identify the presence of mountain waves. The image of 16 June 2015 at 12Z shows a region of mountain waves east of the Andes on the South FIR.

CRITERIA FOR MOUNTAIN WAVE TURBULENCE

Mountain Turbulence at Low Levels (Surface to 5,000 ft/1,500 m over the range)			
Orography Flow Perpendicular to mountain ranges and WS > 24kt and…	**Turbulence Intensity**		
	Light	**Moderate**	**Severe**
Cross-range |dT| at 850 hPa	<6ºC	6ºC-9ºC	> 9ºC
Cross-range |dT/dX| at 850 hPa	<4ºC/60NM	4-6ºC/60NM	>6ºC/60NM
Lee side wind gusts	<25kt	25-50 kt	>50kt
Winds under 500 hPa > 50kt	Increase one level the degree of turbulence already determined (e.g. Increase moderate to severe)		
Cross range dP_{MSL} and Max Winds under 500 hPa	See Nomogram	See Nomogram	See Nomogram

Note: Most intense turbulence category is selected

Source: Michel DAVISON Turbulence Presentation – International Desks

Different parameters are used to determine degree of mountain wave turbulence. To start, a flow perpendicular to the mountain range with wind speeds greater than 24kt is required. This applied to the surface up to 1500m over the mountain range. Five criteria are considered:

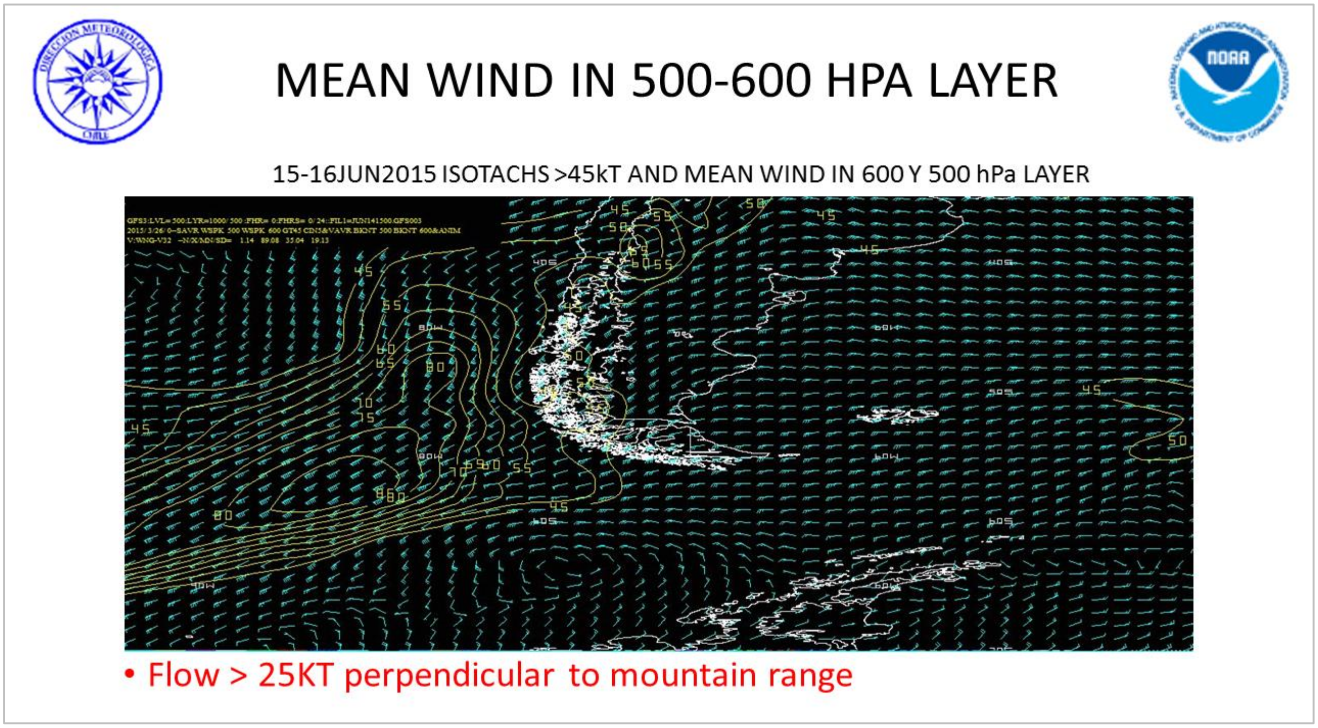
(1) Cross-range temperature change. Temperature increases across the mountain range due to the descent of winds. This generates adiabatic compression and warms the air downstream from the mountain range creating a cross-range temperature gradient.

(2) Cross-range horizontal temperature gradient. This is also related to the previous criteria, but considers distance as well.

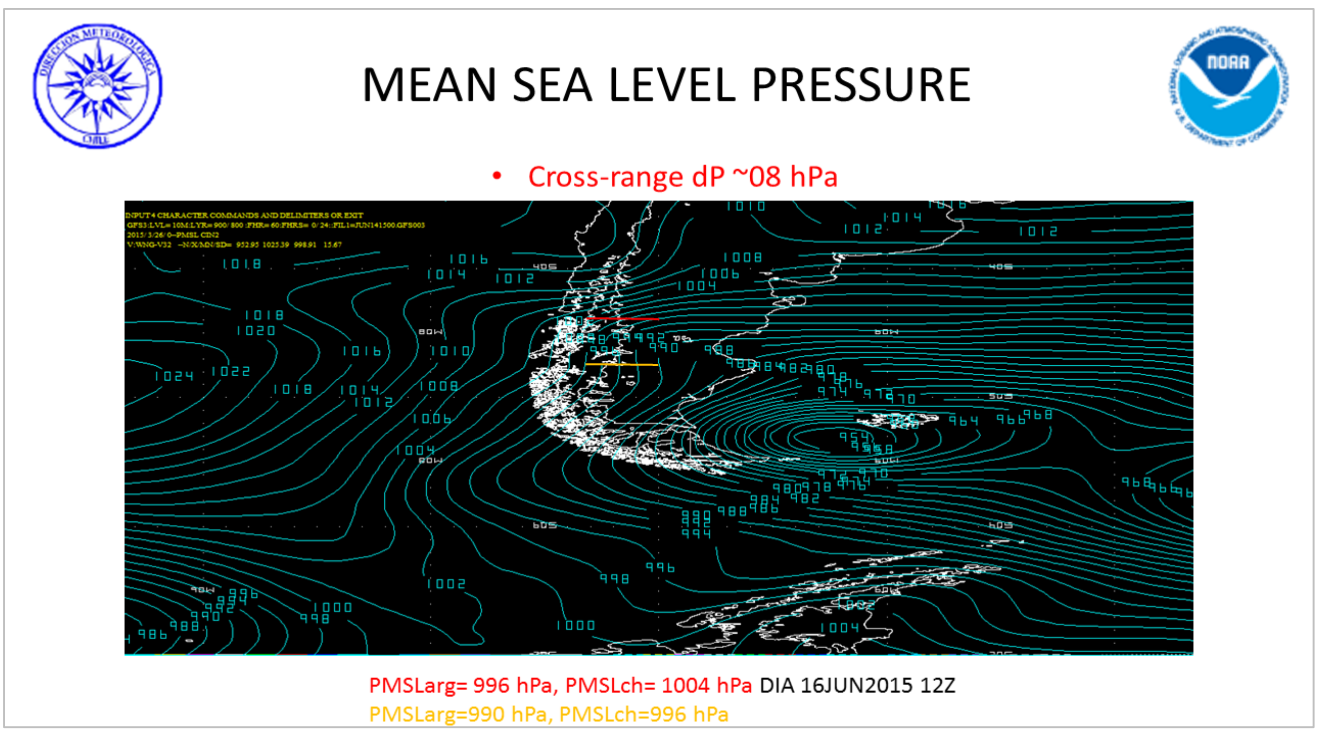
(3) Lee side wind gusts are also an indicator of turbulence. The strongest the wind gusts the more perturbed the layer aloft.

(4) If the winds at 500 hPa are greater than 50kt, the degree of turbulence forecast is increased in one category.

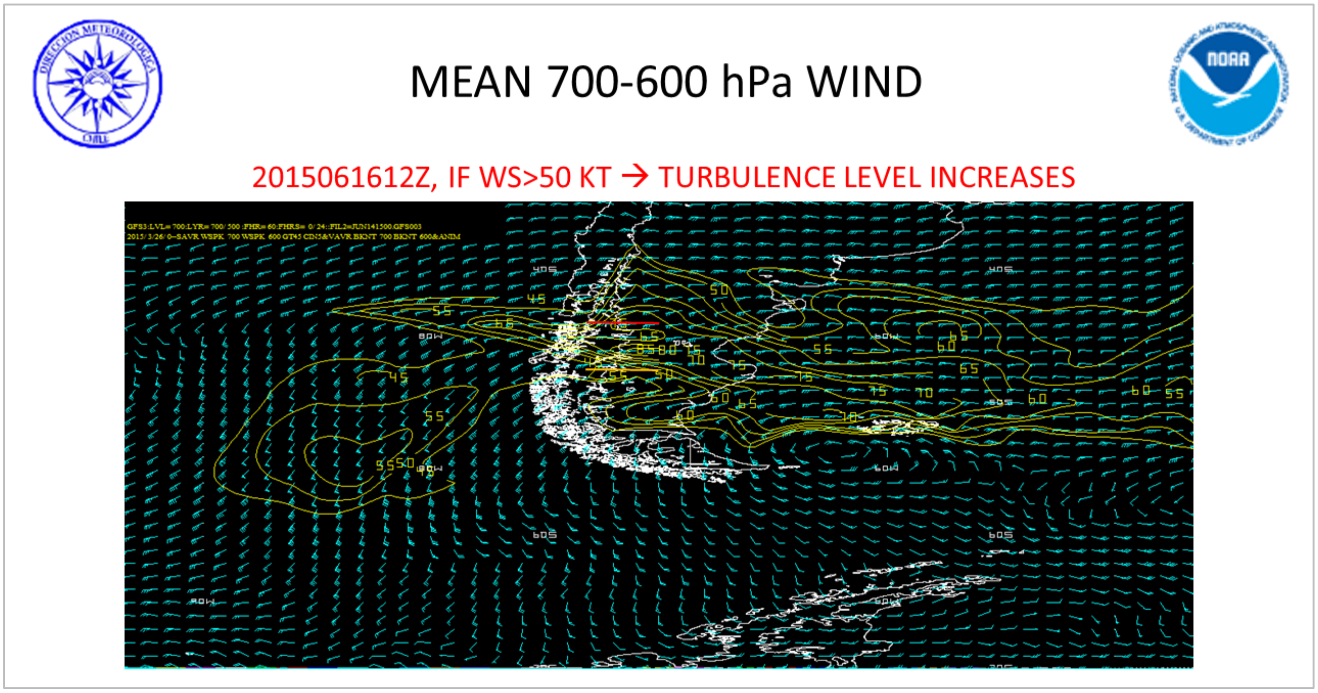
(5) Nomogram analysis. This is a conjunct analysis of the cross-range pressure change and the cross-range wind speed change.



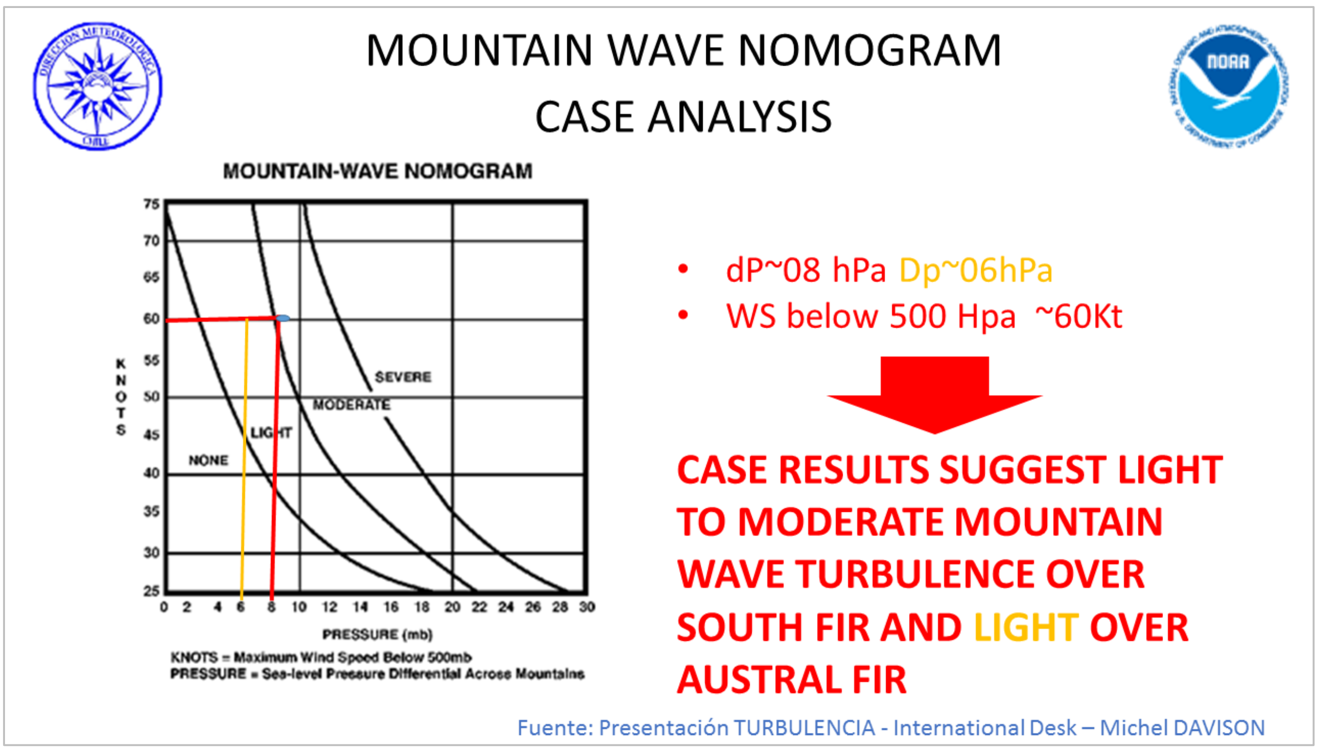
Using GFS model data, the potential for mountain wave turbulence is first evaluated by identifying winds > 25kt that are perpendicular to the mountain range. These are found, thus the potential of mountain wave turbulence exists and an intensity analysis needs to be performed.



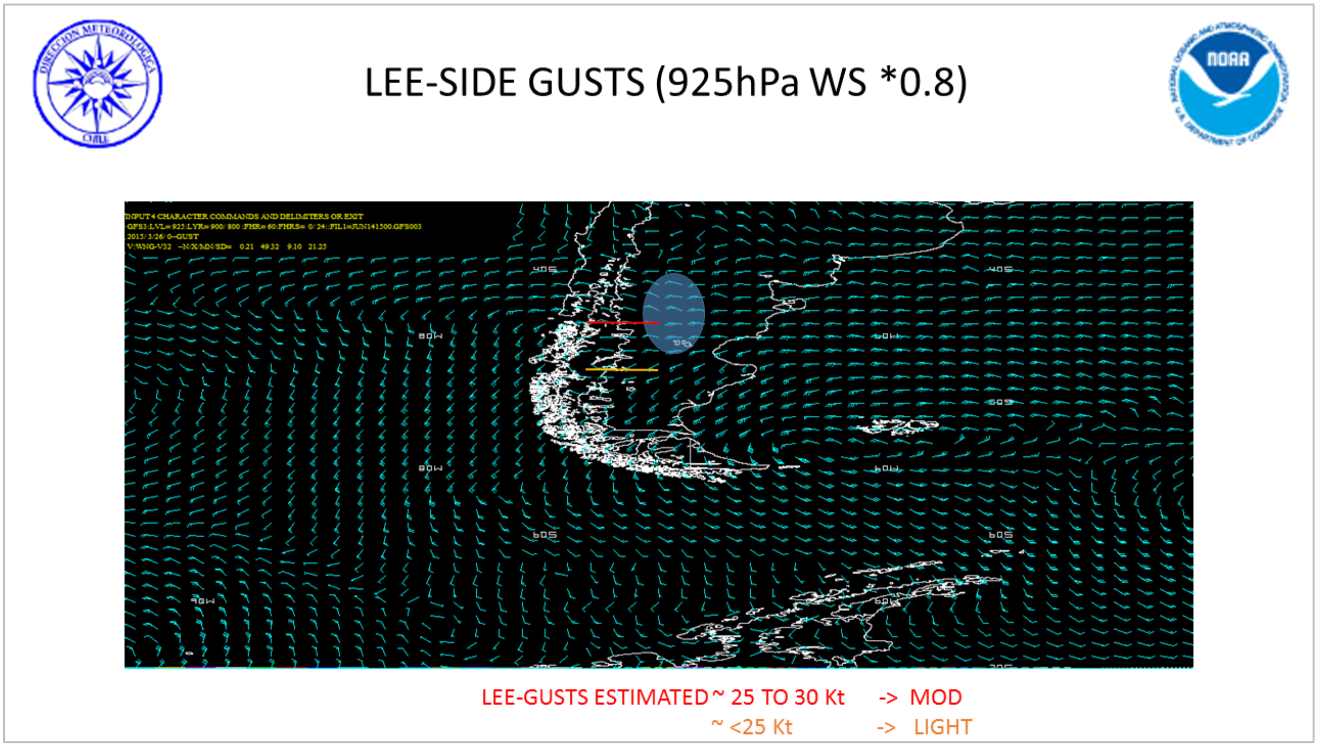
The mean sea level pressure from GFS data allows the computation of dP for two parts of the mountain range. It is dP~8hPa for the north and ~6hPa for the south.



Winds approach speeds of 60kt in the region of interest.

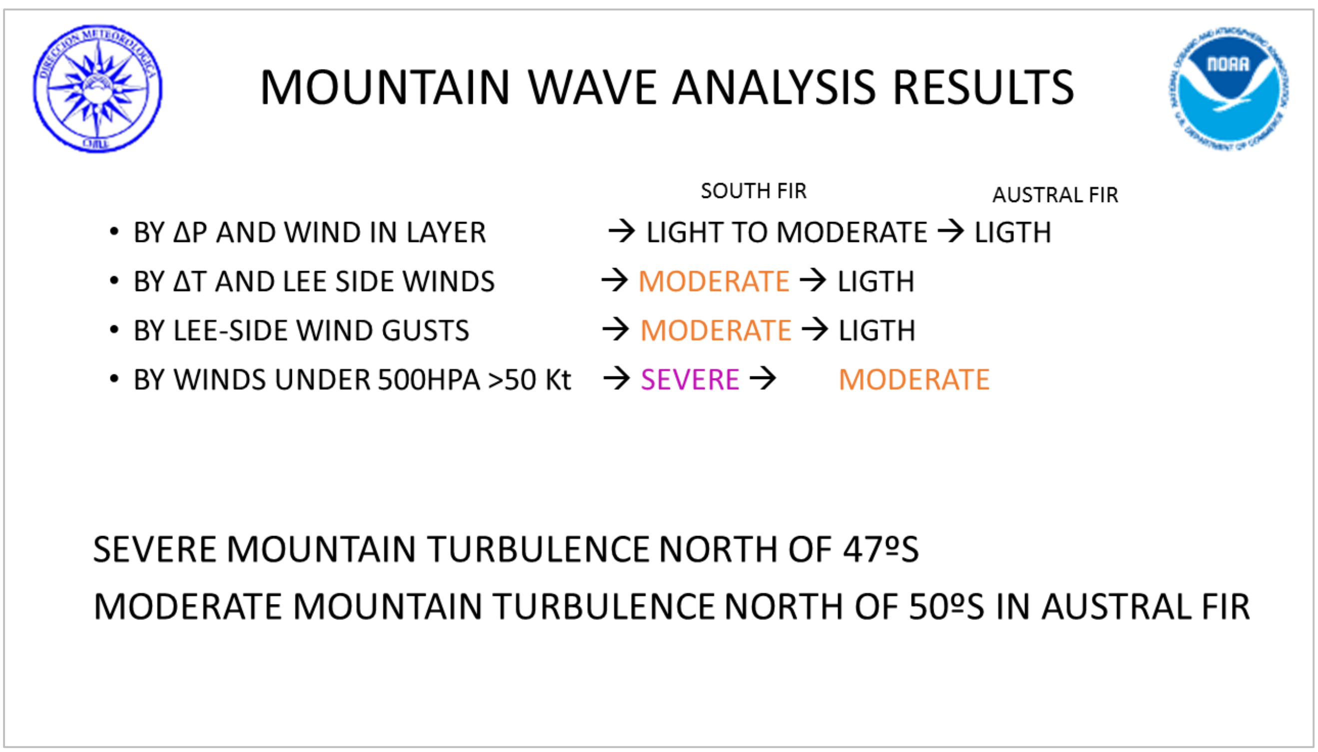


When the dP and wind speed data are placed in the Nomogram, mountain turbulence classifies as moderate for the Southern FIR (red) and light for the Austral Fir (yellow).

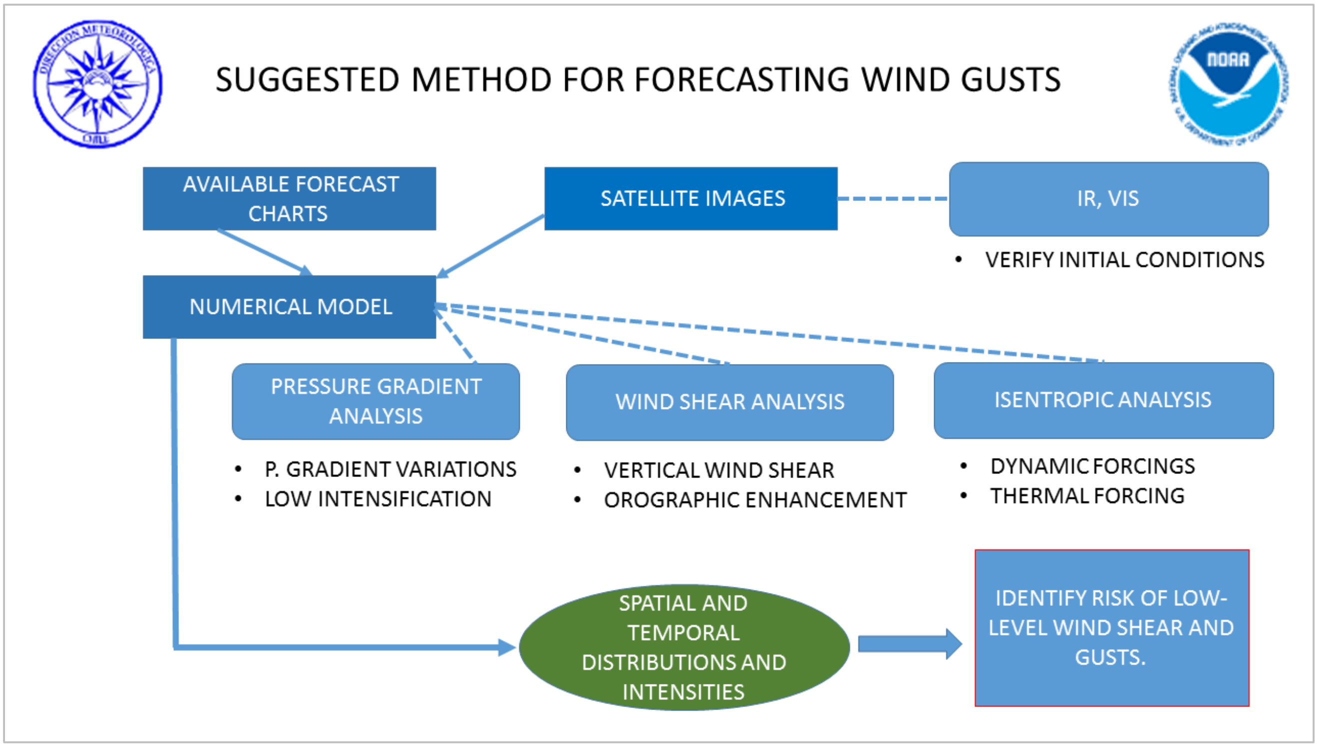


Another method used to estimate the speed of surface wind gusts is to take the 80% of the 925 hPa wind speed (WPC, personal communication 2015). When this is applied, the estimated wind gusts are between 25 and 30kt in the Southern Fir (red) and less than 25kt in the Austral Fir (yellow).

The following slide summarizes the results.

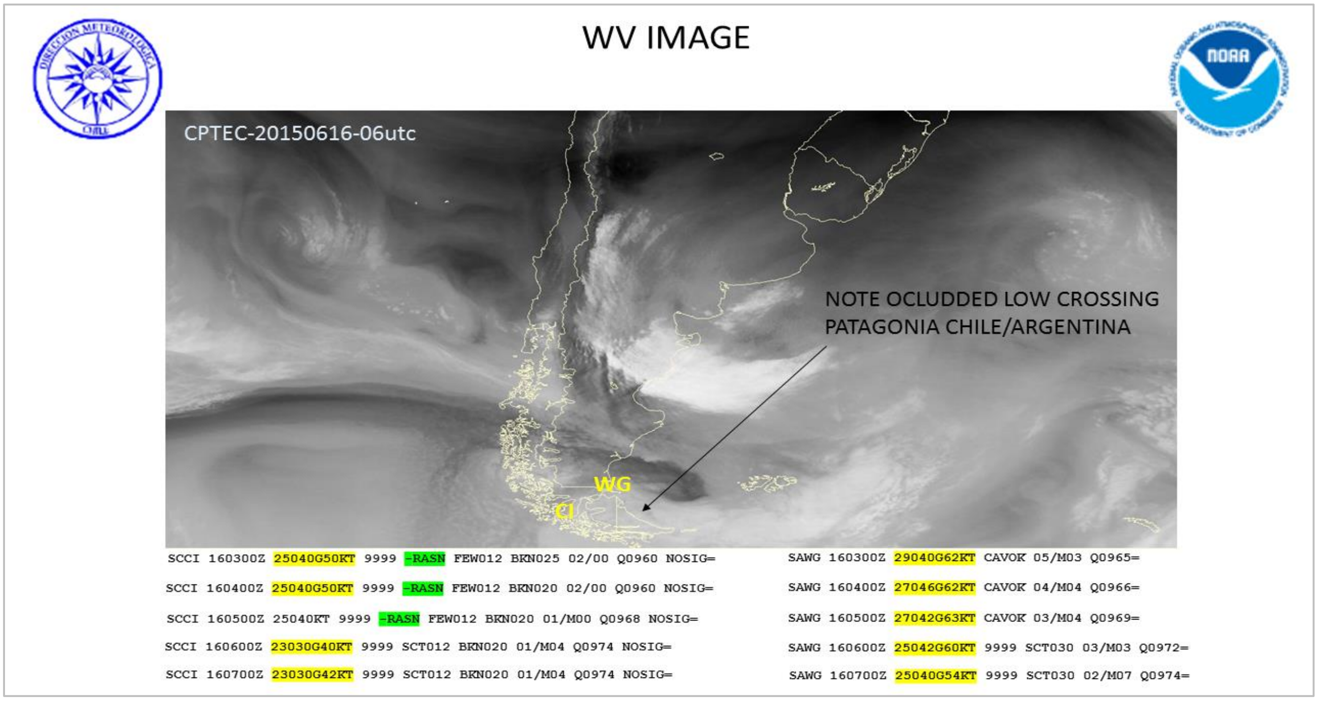


ASSESSING POTENTIAL FOR NEAR SURFACE WIND GUSTS

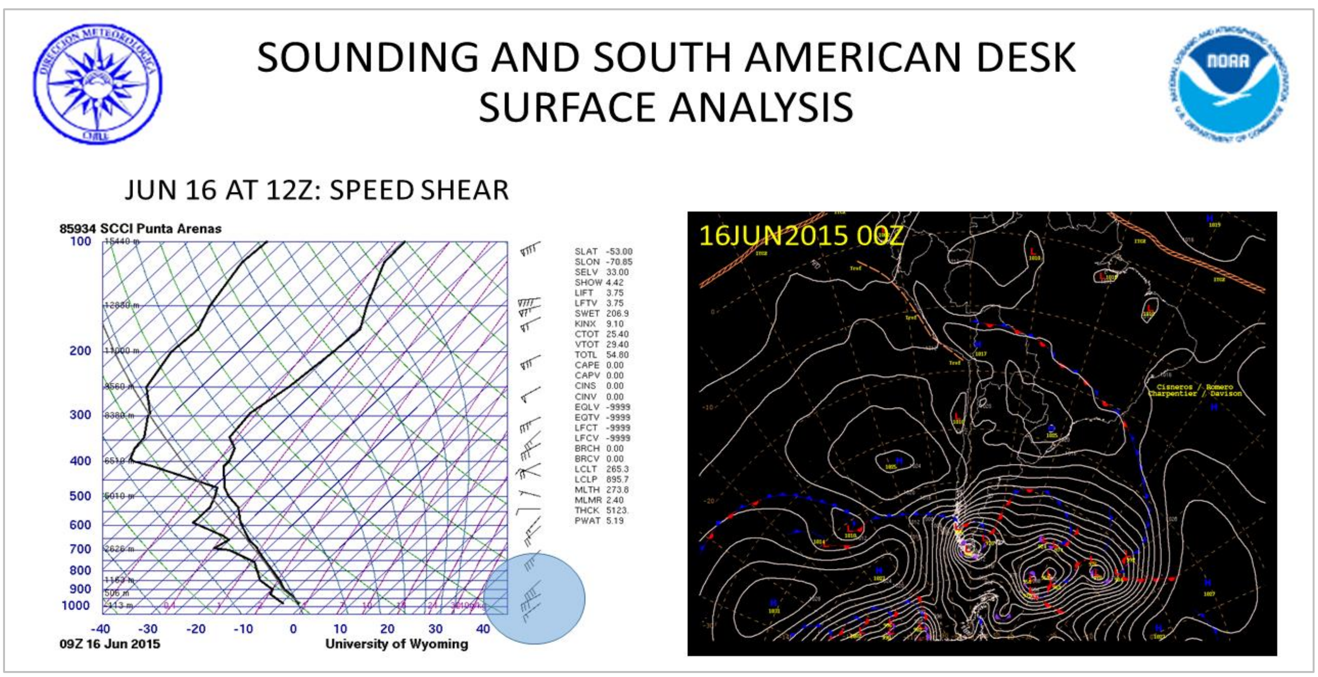


A method is proposed for the forecasting of near surface wind gusts. It considers the analysis of available forecast charts and verification via satellite imagery, and then uses numerical model data to perform (1) a pressure gradient analysis, (2) a wind shear analysis and (3) an isentropic analysis.

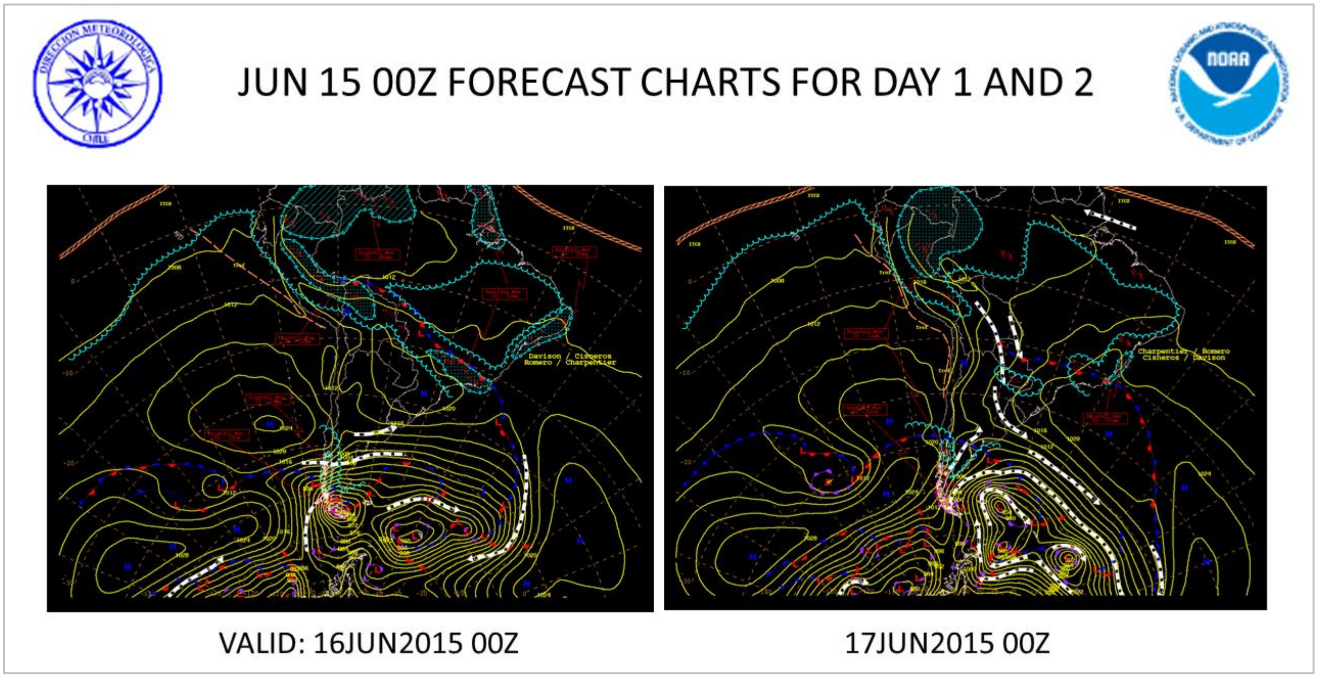
The method is applied to the 15-16 June 2015 case of strong wind gusts in Punta Arenas, Chile (SCCI).



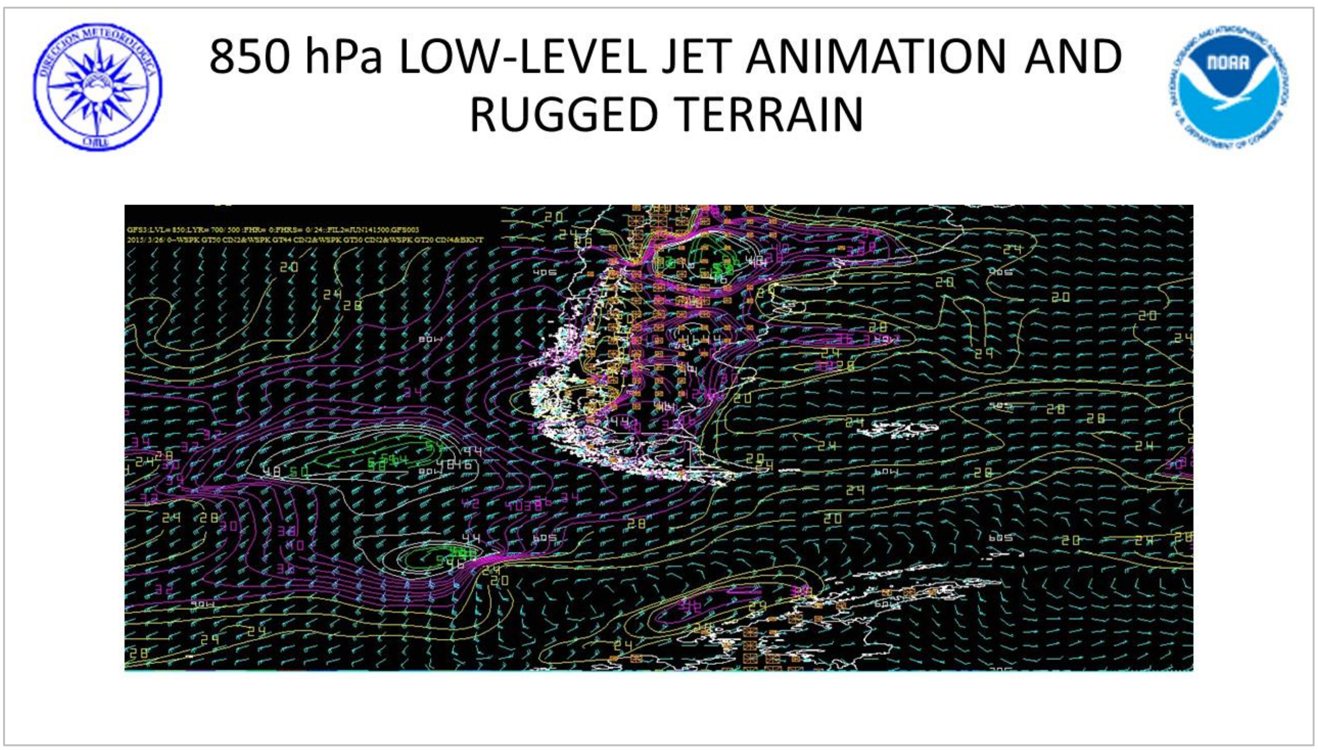
The satellite image shows the passage of an occluded low crossing Tierra del Fuego, or the southern tip of South America. The location of Punta arenas (SCCI) and Rio Gallegos (SAWG) is indicated. Metar observations from both stations show the presence of wind gusts. The gusts reached 50kt in Punta Arenas and 63kt in Rio Gallegos.



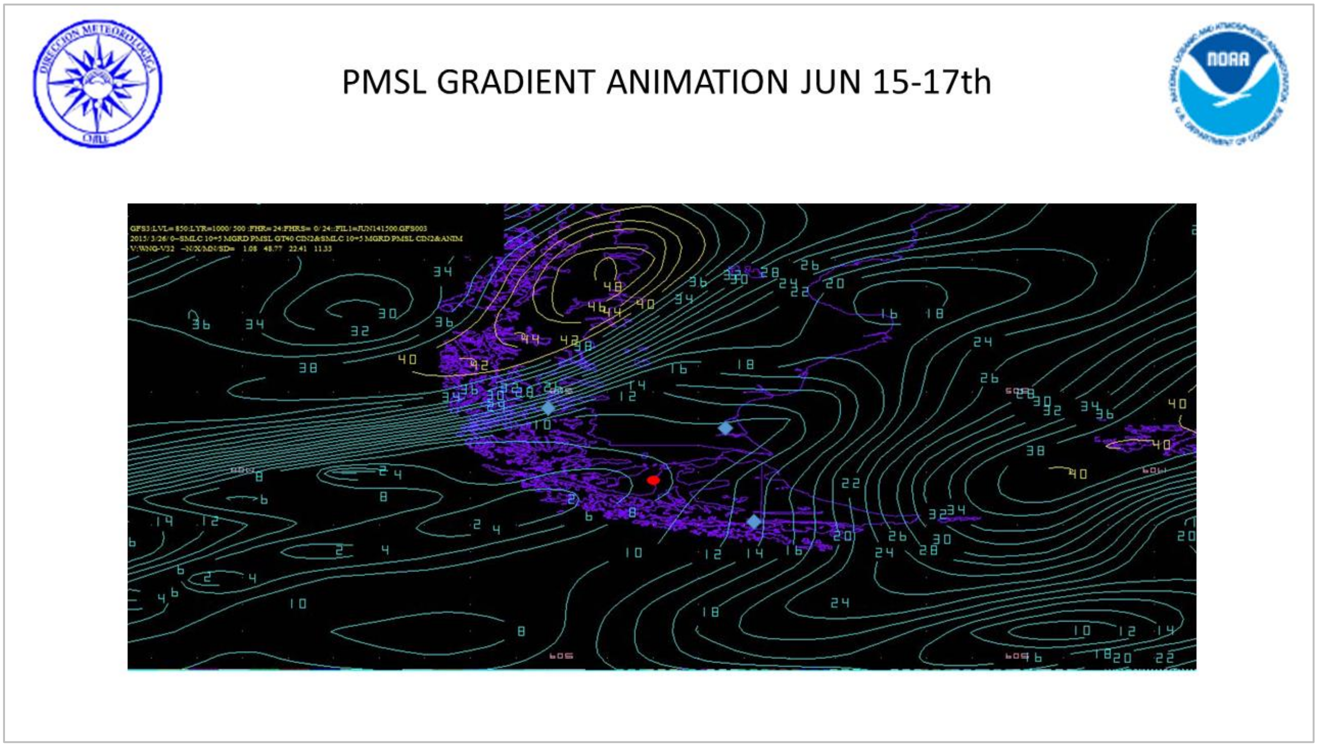
The South American Desk surface analysis shows the passage of the occluded low accompanied by a tight pressure gradient. The SCCI sounding shows speed shear between 800 hPa and 1000 hPa.



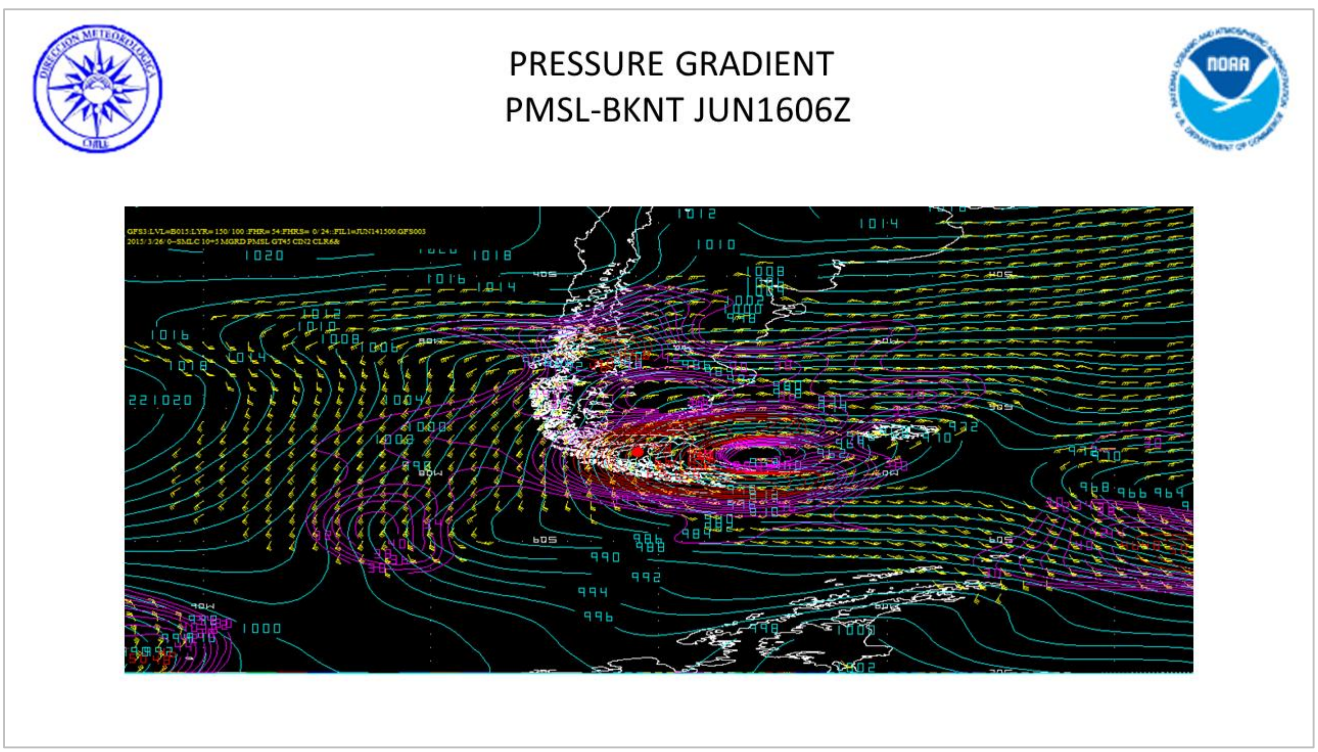
The South American Desk forecast charts show the passage of the occluded low accompanied by strong low-level jets.



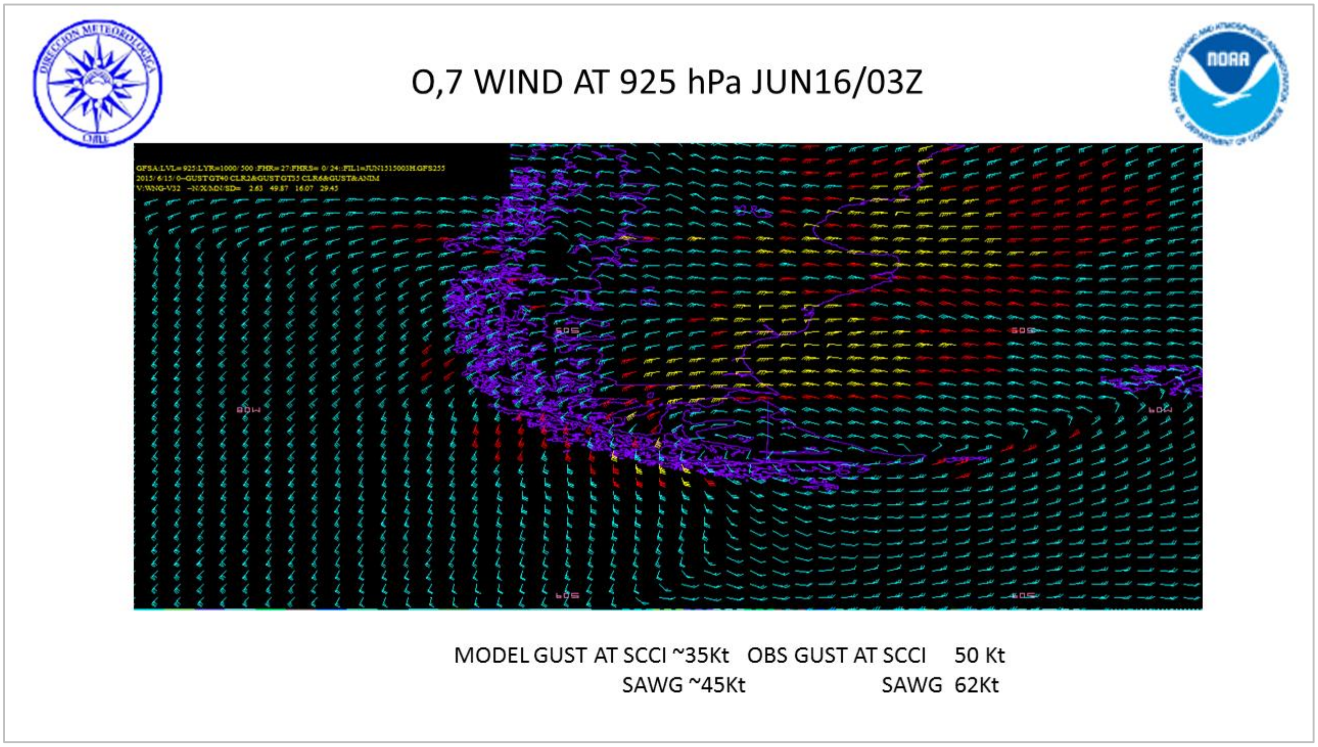
This slide contains an animation that is not visible on the PDF. The animation shows the progression of the low-level jet to the north of the occluded low into the mountains of Southern South America.



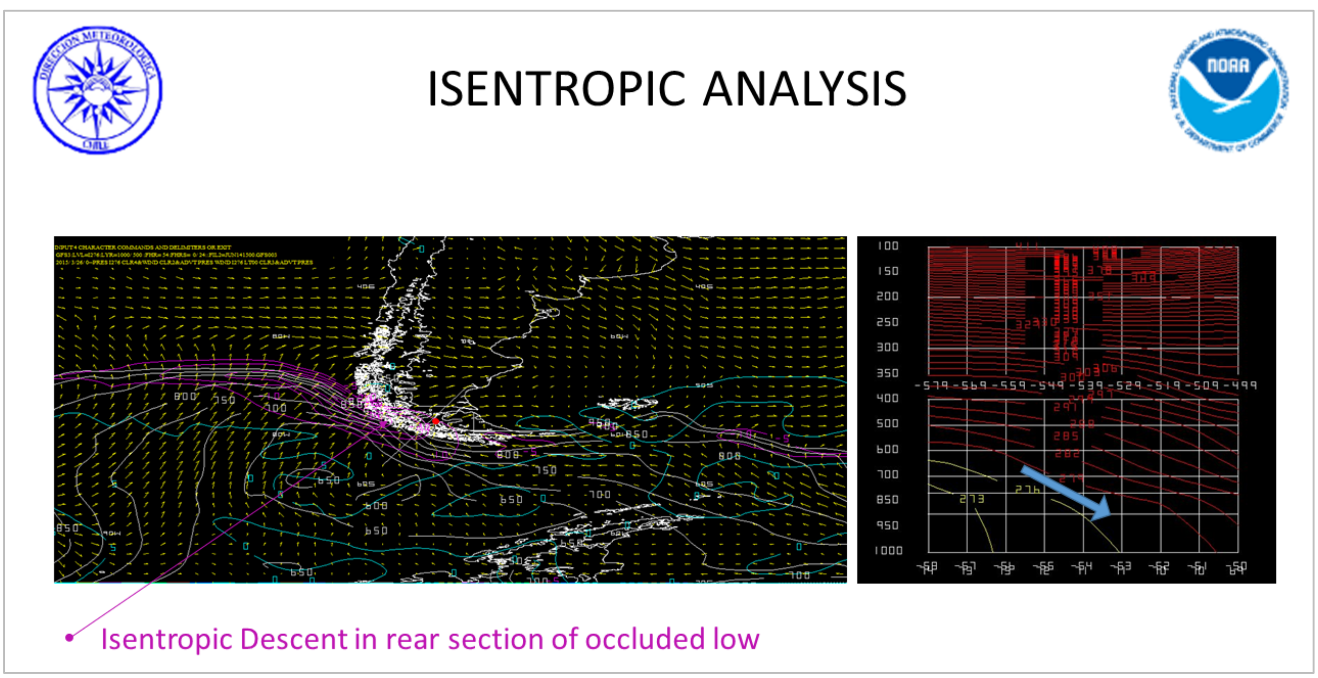
This slide contains an animation that is not visible on the PDF. The mean sea level pressure gradient provides an idea of the wind speed. This animation shows the evolution of large pressure gradients over/near SCCI.



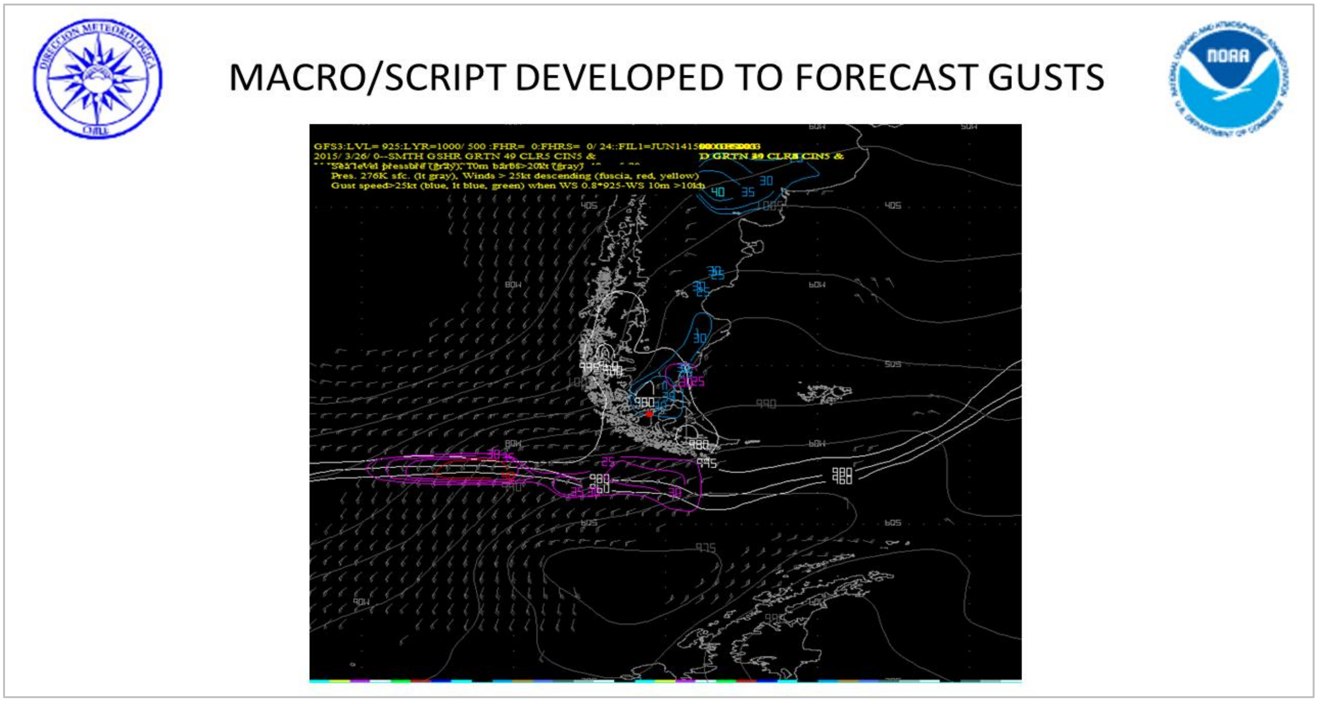
This is another way to visualize the strong pressure gradient and the strongest winds.

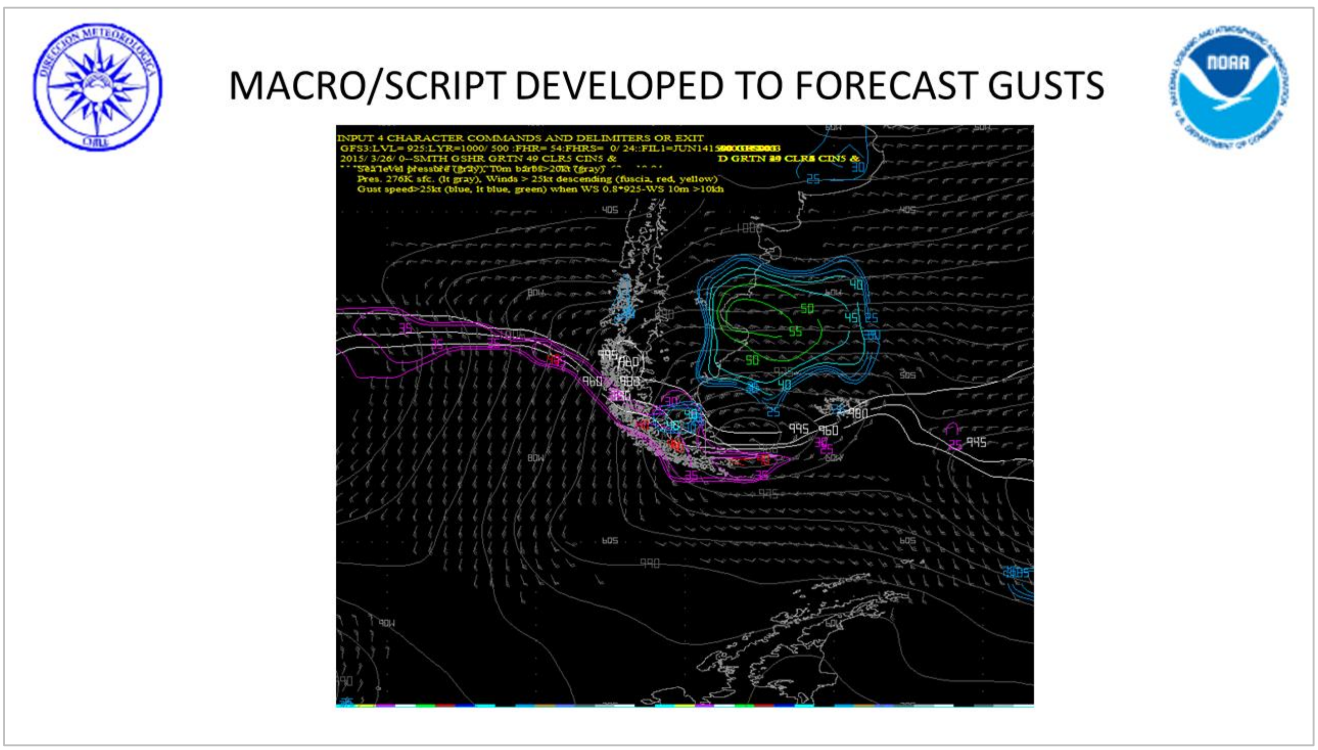


The aforementioned method of considering 70-80% of the 925 wind speeds to estimate surface wind gusts was applied to GFS data. This produced an underestimation of the observed wind gusts as 50kt were observed in Punta Arenas versus 35kt proposed by the model; and 62kt in Rio Gallegos versus 45kt proposed by the model.



One process identified was isentropic descent in the rear side of the occluded low. When the baroclinicity is large and a cold air mass lies upstream, winds are forced to descend. This increases the speed of surface gusts.





A macro/script was developed to forecast wind gusts (see the appendix). The macro/script shows that two of the methods explored as tools to identify the potential for wind gusts were suggesting it for the early morning of 16 June 2015. Gusts were associated with the vertical shear in the boundary layer and isentropic descent in the rear side of occluded lows.

SUMMARY

- MID-LEVEL TURBULENCE: MOUNTAIN WAVE TURBULENCE WAS MODERATE (OCASSIONALY SEVERE NORTH OF (47S).
- SURFACE WIND GUSTS: PRESENT IN ASSOCIATION WITH STRONG PRESSURE GRADIENT AND LOW-LEVEL SHEAR; AND ISENTROPIC DESCENT IN ASSOCIATION WITH OCCLUDED LOW/COLD AIR MASS.

CONTRIBUTIONS

- TESTED METHODOLOGY TO EVALUATE THE POTENTIAL FOR TURBULENCE ASSOCIATED WITH MOUNTAIN WAVES.
- PROPOSED METHODOLOGY TO ESTIMATE THE CHANCE AND SPEED OF WIND GUSTS IN ASSOCIATION WITH ISENTROPIC DESCENT IN THE REAR TIER OF OCCLUDED LOWS.

References

Davison M., 2015: Turbulence Presentation WPC International Desks.

APPENDIX

WINGRIDDS macros/scripts were generated to identify the potential for wind gusts associated with isentropic descent in the back side of occluded lows. The macros/scripts also plot the difference in 10m winds and 80% of the 925hPa winds. The larger this difference the larger the potential for gusts in association with vertical wind shear. Four scripts/macros are presented: GST1.CMD, GST2.CMD, GST3.CMD and GST4.CMD. These use different isentropic surfaces since their elevation depend on the temperature of the air mass. Colder air masses require the use of lower isentropes (e.g. GST1.CMD uses the 276K isentropic surface) while warmer air masses require the use of warmer isentropes (e.g. GST4.CMD uses the 285K isentrope). The GST*.CMD macros/scripts plot the pressure of the isentropic surface, the negative advection of pressure by the wind (indicates isentropic descent), winds over 40kt and sea level pressure.

The following code needs to be added to the ALIAS.USR file to calculate the variable GS01 (estimation of near surface wind gusts based on the difference between the 80% of 925 hPa winds and 10m winds.

@@@@ WIND GUST FORECASTING BEGINS @@@@@@@
@@@@@@@@@@@@@@@@@@@@@@@@@@

GS01=SMTH SDIF SMLC 0.8 MAGN WIND 925 MAGN WIND 10M
@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@@@ WIND GUST FORECASTING ENDS
@@@@@@@@@@@@@@@@@@@@@@@@@@@@

(1) GST1.CMD

```
LOOP
I276
SMTH PRES LSTN 1000 GRTN 945 CI20 CLR1
I276
SMTH PRES LSTN  945 GRTN 600 CI50 CLR1/
I276
SMTH SMLC  1+3 ADVT PRES WIND LSTN -2.1 CIN1 CLR3 DOTS NCLB/
SMTH SMLC  1+3 ADVT PRES WIND LSTN -6.1 CIN1 CLR3 NCLB/
I276
BKNT GRTN   40 CLR2/
PMSL LSTN 1016 CIN5 CLR2/
SDIF SMLC  0.8 MAGN WIND  925 MAGN WIND  10M GRTN   6 CLR6 CIN1/
TXT3 ******WIND GUST FORECASTING FOR SOUTHERN SOUTH AMERICA*******
TXT4 ***Gina Charpentier, Jose M. Galvez and Mike Davison, 2015***
TXT5 Pressure of 276K surface (lt blue), Winds 276K surface (yellow)
TXT6 Isentropic descent (fuscia dots), Sea level pressure (yellow),
TXT7 Wind speed difference between Wind_925*0.8 and Winds at 10m (red)
ENDL
```

(2) GST2.CMD

```
LOOP
I279
SMTH PRES LSTN 1000 GRTN 945 CI20 CLR1
I279
SMTH PRES LSTN  945 GRTN 600 CI50 CLR1/
I279
SMTH SMLC  1+3 ADVT PRES WIND LSTN -2.1 CIN1 CLR3 DOTS NCLB/
SMTH SMLC  1+3 ADVT PRES WIND LSTN -6.1 CIN1 CLR3 NCLB/
I279
BKNT GRTN   40 CLR2/
PMSL LSTN 1016 CIN5 CLR2/
SDIF SMLC  0.8 MAGN WIND  925 MAGN WIND  10M GRTN   6 CLR6 CIN1/
TXT3 ******WIND GUST FORECASTING FOR SOUTHERN SOUTH AMERICA*******
TXT4 ***Gina Charpentier, Jose M. Galvez and Mike Davison, 2015***
TXT5 Pressure of 279K surface (lt blue), Winds 276K surface (yellow)
TXT6 Isentropic descent (fuscia dots), Sea level pressure (yellow),
TXT7 Wind speed difference between Wind_925*0.8 and Winds at 10m (red)
ENDL
```

(3) GST3.CMD

```
LOOP
I282
SMTH PRES LSTN 1000 GRTN 945 CI20 CLR1
I282
SMTH PRES LSTN  945 GRTN 600 CI50 CLR1/
I282
SMTH SMLC  1+3 ADVT PRES WIND LSTN -2.1 CIN1 CLR3 DOTS NCLB/
SMTH SMLC  1+3 ADVT PRES WIND LSTN -6.1 CIN1 CLR3 NCLB/
I282
BKNT GRTN   40 CLR2/
PMSL LSTN 1016 CIN5 CLR2/
SDIF SMLC  0.8 MAGN WIND  925 MAGN WIND  10M GRTN   6 CLR6 CIN1/
TXT3 ******WIND GUST FORECASTING FOR SOUTHERN SOUTH AMERICA*******
TXT4 ***Gina Charpentier, Jose M. Galvez and Mike Davison, 2015***
TXT5 Pressure of 282K surface (lt blue), Winds 282K surface (yellow)
TXT6 Isentropic descent (fuscia dots), Sea level pressure (yellow),
TXT7 Wind speed difference between Wind_925*0.8 and Winds at 10m (red)
ENDL
```

(4) GST4.CMD

```
LOOP
I285
SMTH PRES LSTN 1000 GRTN 945 CI20 CLR1
I285
SMTH PRES LSTN  945 GRTN 600 CI50 CLR1/
I285
SMTH SMLC  1+3 ADVT PRES WIND LSTN -2.1 CIN1 CLR3 DOTS NCLB/
SMTH SMLC  1+3 ADVT PRES WIND LSTN -6.1 CIN1 CLR3 NCLB/
I285
BKNT GRTN   40 CLR2/
PMSL LSTN 1016 CIN5 CLR2/
SDIF SMLC  0.8 MAGN WIND  925 MAGN WIND  10M GRTN   6 CLR6 CIN1/
TXT3 ******WIND GUST FORECASTING FOR SOUTHERN SOUTH AMERICA*******
TXT4 ***Gina Charpentier, Jose M. Galvez and Mike Davison, 2015***
TXT5 Pressure of 285K surface (lt blue), Winds 285K surface (yellow)
TXT6 Isentropic descent (fuscia dots), Sea level pressure (yellow),
TXT7 Wind speed difference between Wind_925*0.8 and Winds at 10m (red)
ENDL
```