Andean Glacier Mass Balance Modeling from Dynamically Downscaled Climate: Challenges and Opportunities

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Overview

- South America glaciers
- Modeling Andean glaciers
- Our Modeling approach
- Some regional results
- Dynamical Downscaling from WRF
- Final comments

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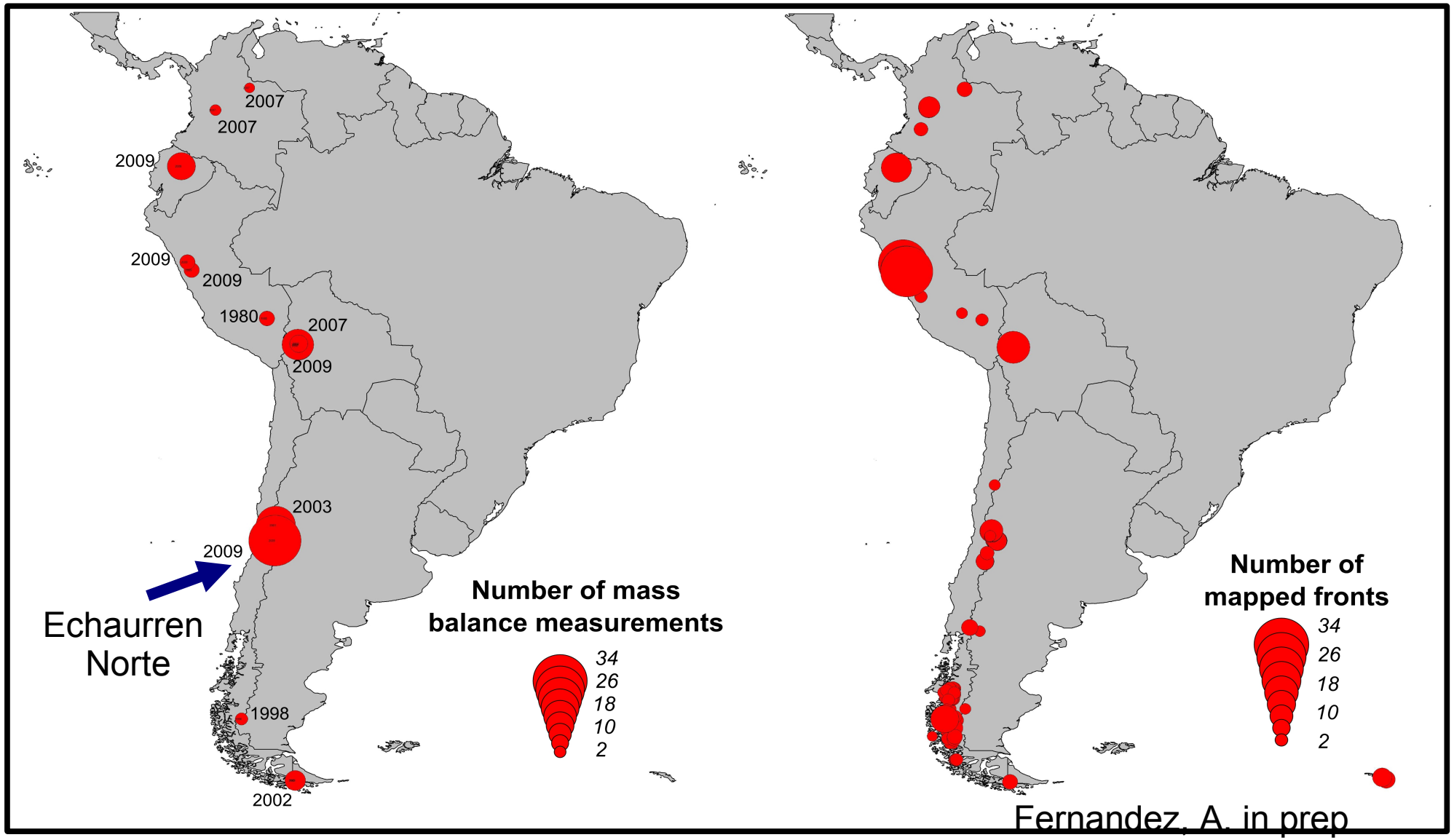
Observations and measurements

6000 inventoried glaciers.
Few observed glaciers, short databases.



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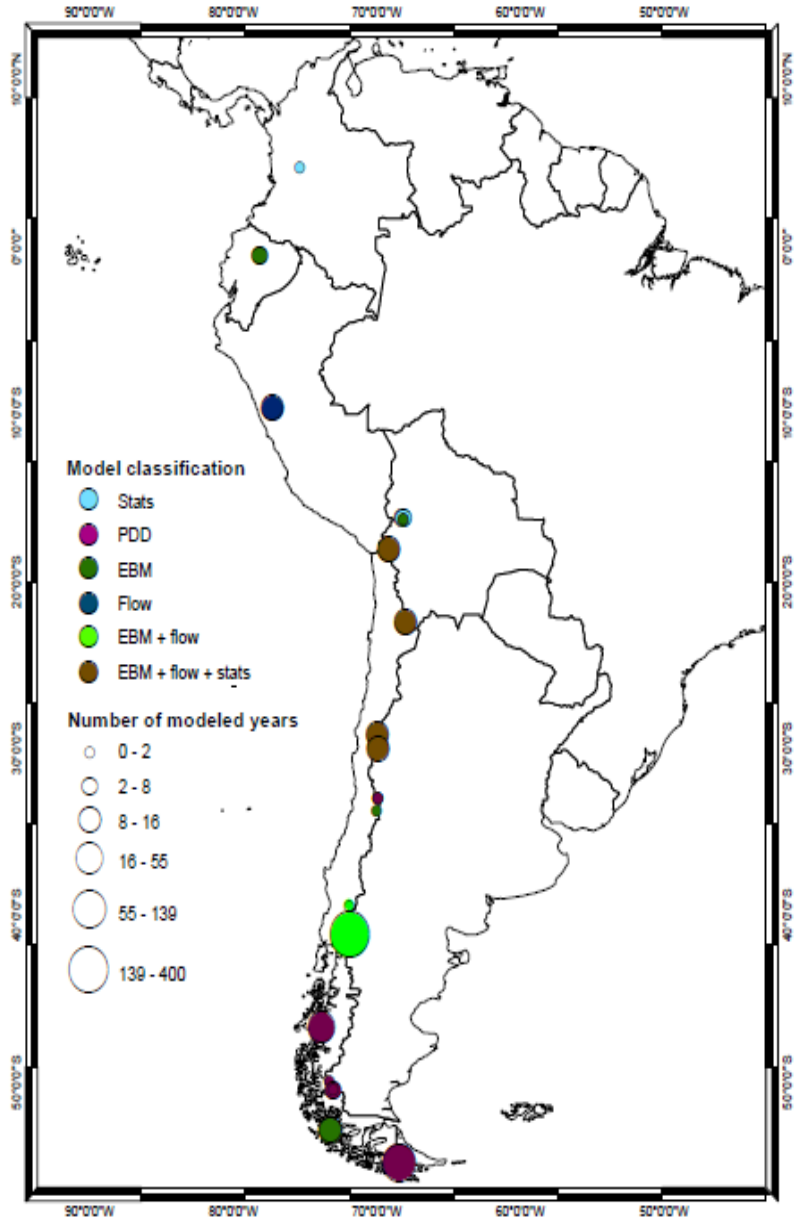
Modeling Andean glaciers

- Some remarks on what we know
- One Continental approach (statistical).
- A couple “specific region” approaches (Cordillera Blanca, North Patagonia).
- Models' time-windows span from a few months to several centuries (no trend).
- Most short range models are concerned with melt processes at point scale (glacier tongue).
- Most long term modeling finds that temperature is the main driver of changes.



Fernandez, A in prep

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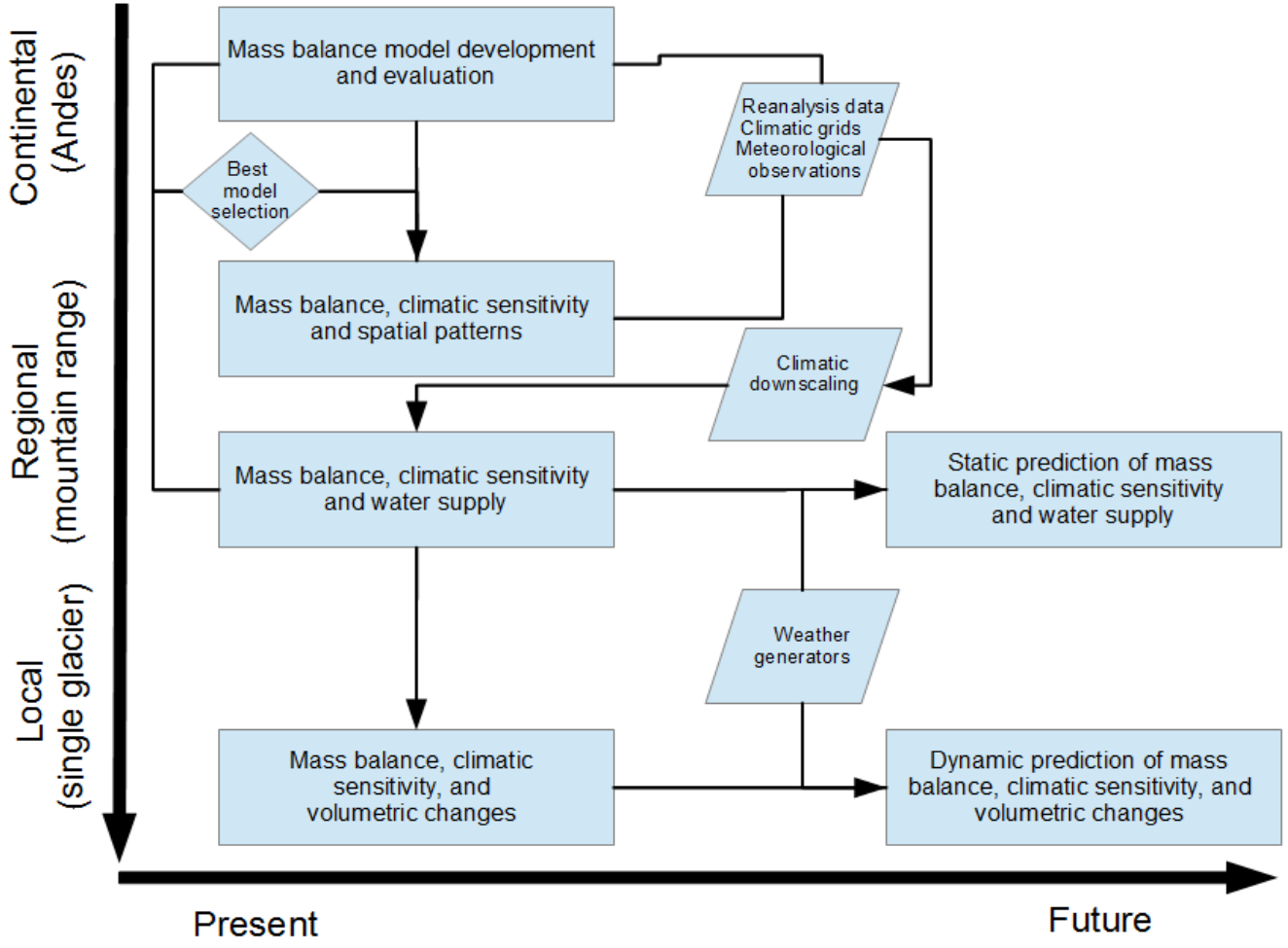
Our modeling approach
What do we want to know?

Modeling focused on the satellite era (1979 onwards)



Continental mass balance trends

Can we use global databases to understand regional changes glacier changes?

Do SA glaciers behave similarly?

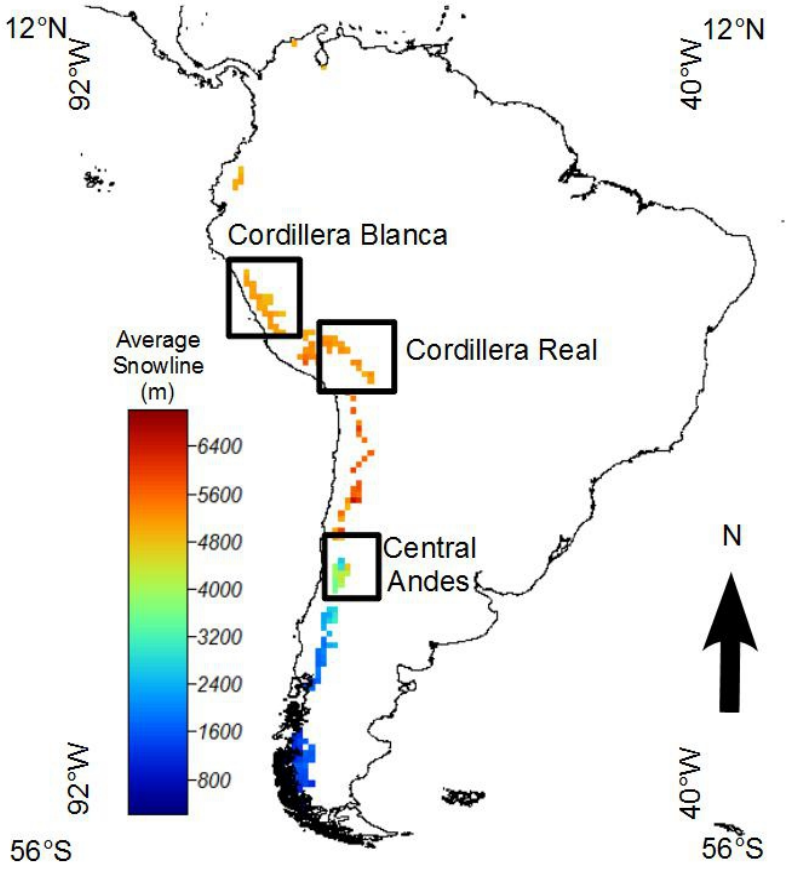
Is that behavior unexpected?

Can we identify locations with significant changes (statistically speaking)?

To improve our current knowledge on glacier sensitivity to climate changes and the impact of glacier changes on mountain water resources

Continental modeling

- **Comparing the accuracy of different approaches to model mountain glacier mass balance.**
- At a continental level and between the two most common techniques: Degree day factor (DDF) and Energy mass balance (EMB) models. On the few places longterm mass balance program exist.
- Select the most suitable global database to force the model.
- We expect general trends to be reproduced, not actual numbers.
- CRU, Delaware, CSFR, and ERA. They represent different spatial resolutions and techniques.



Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful (Box and Draper, 1987)

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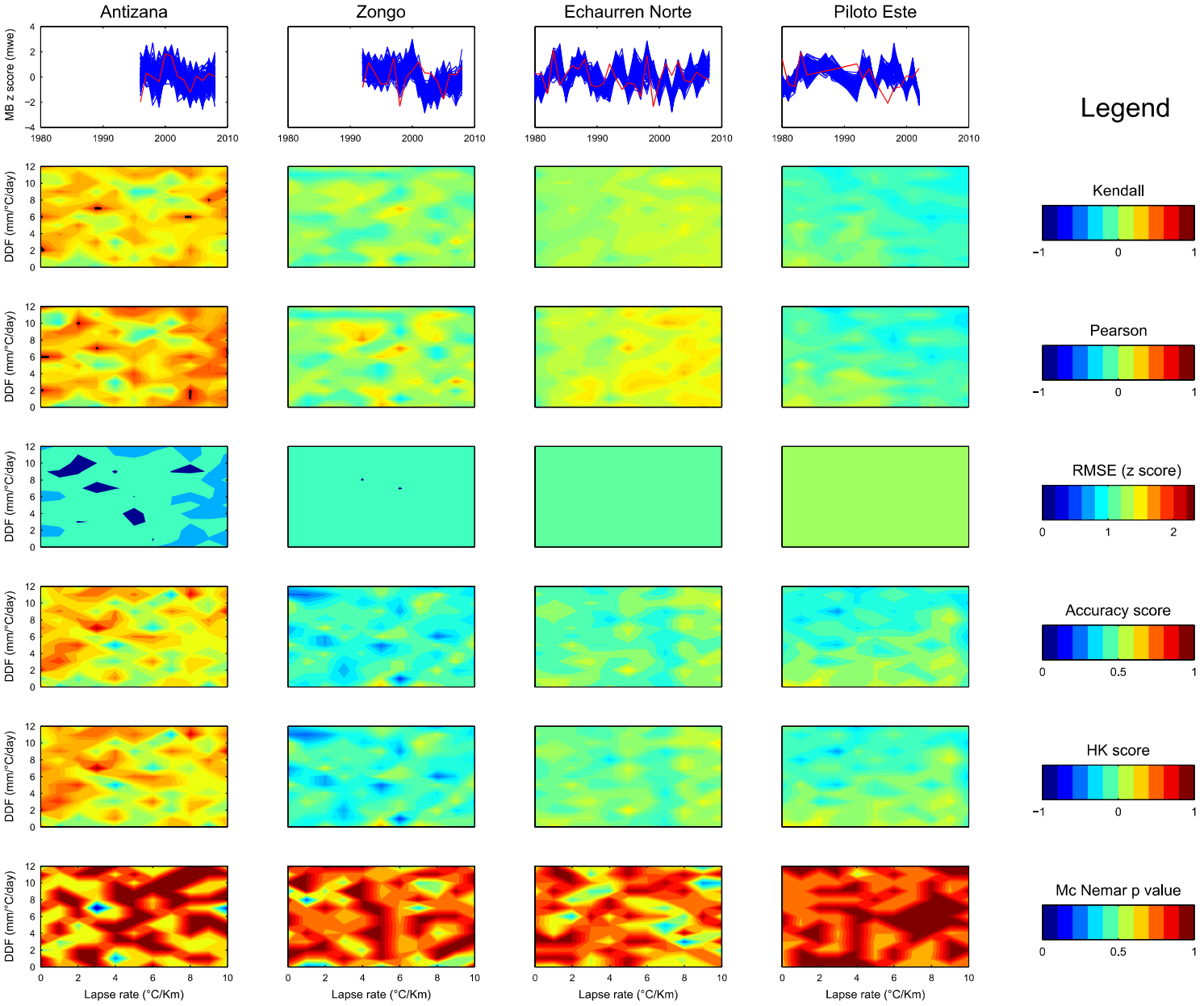
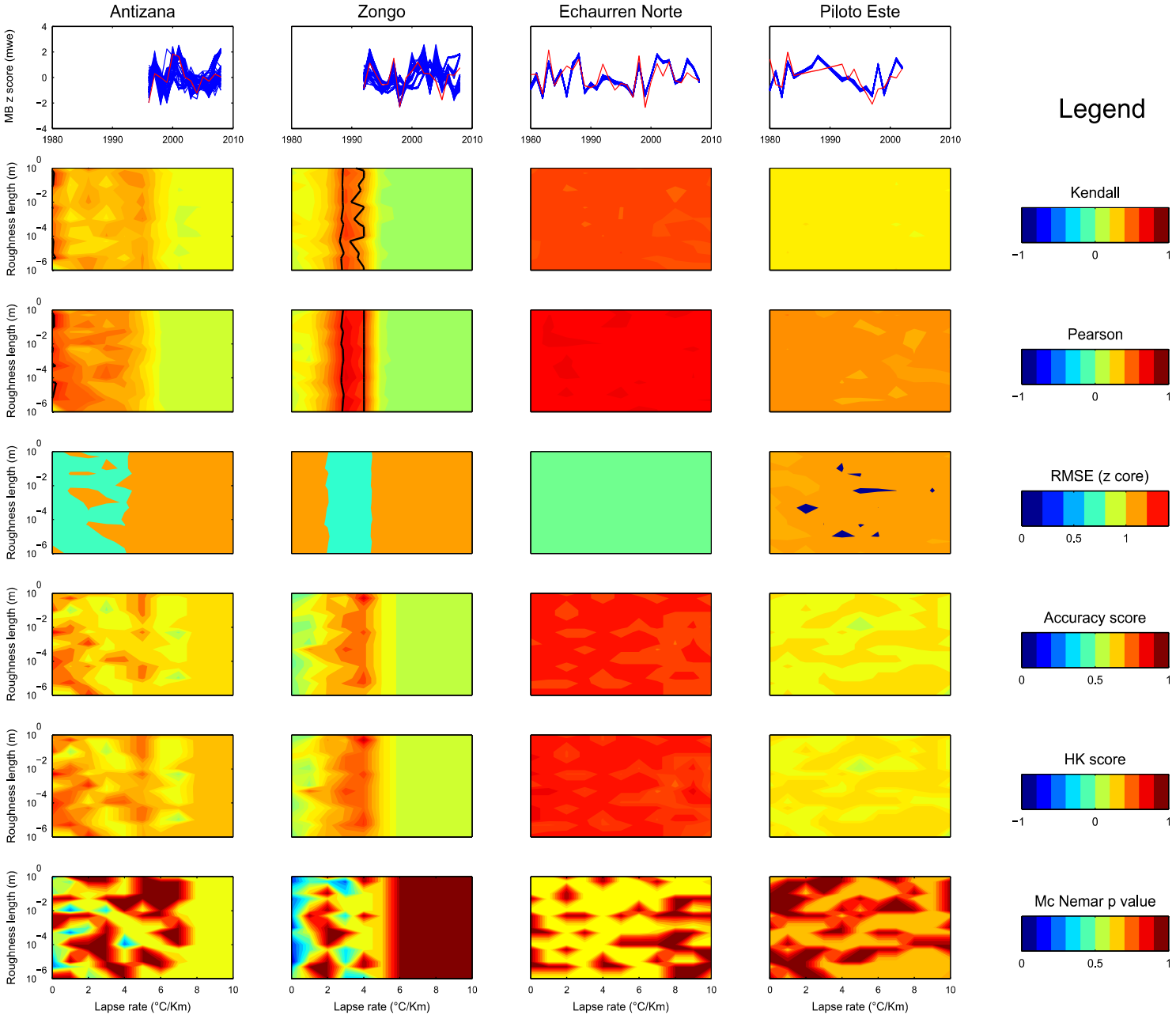
DDF forced by Delaware grids

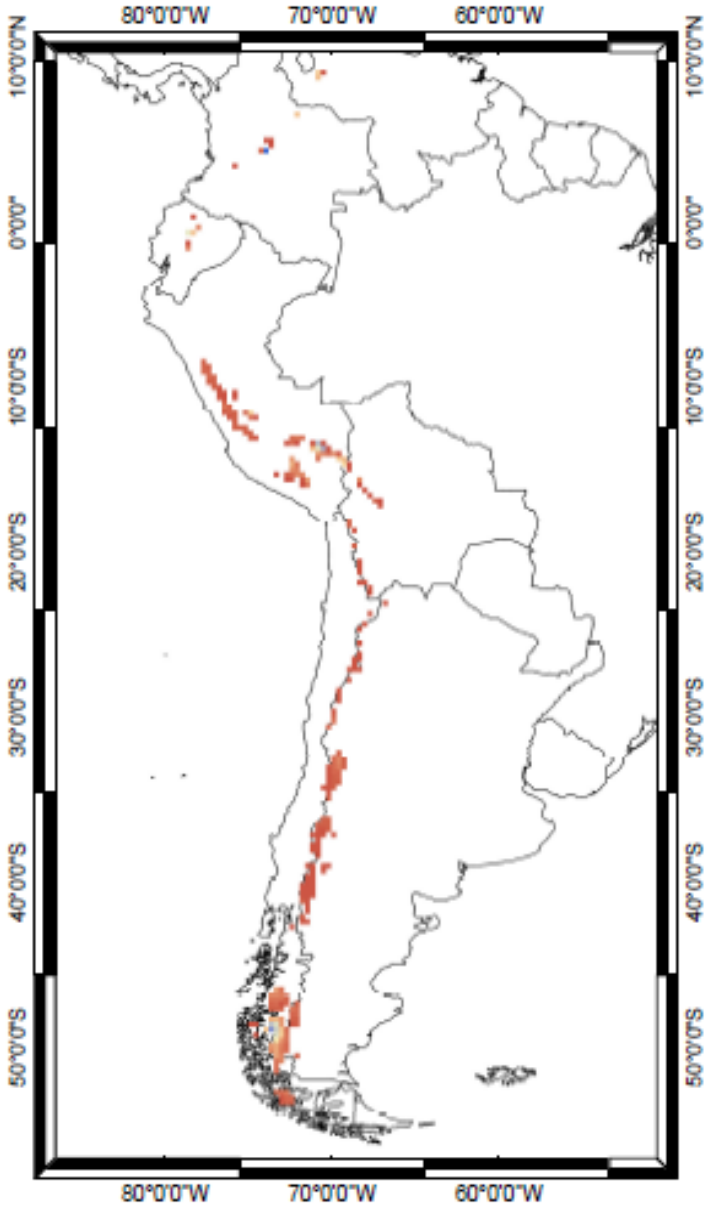


EBM forced by CFSR

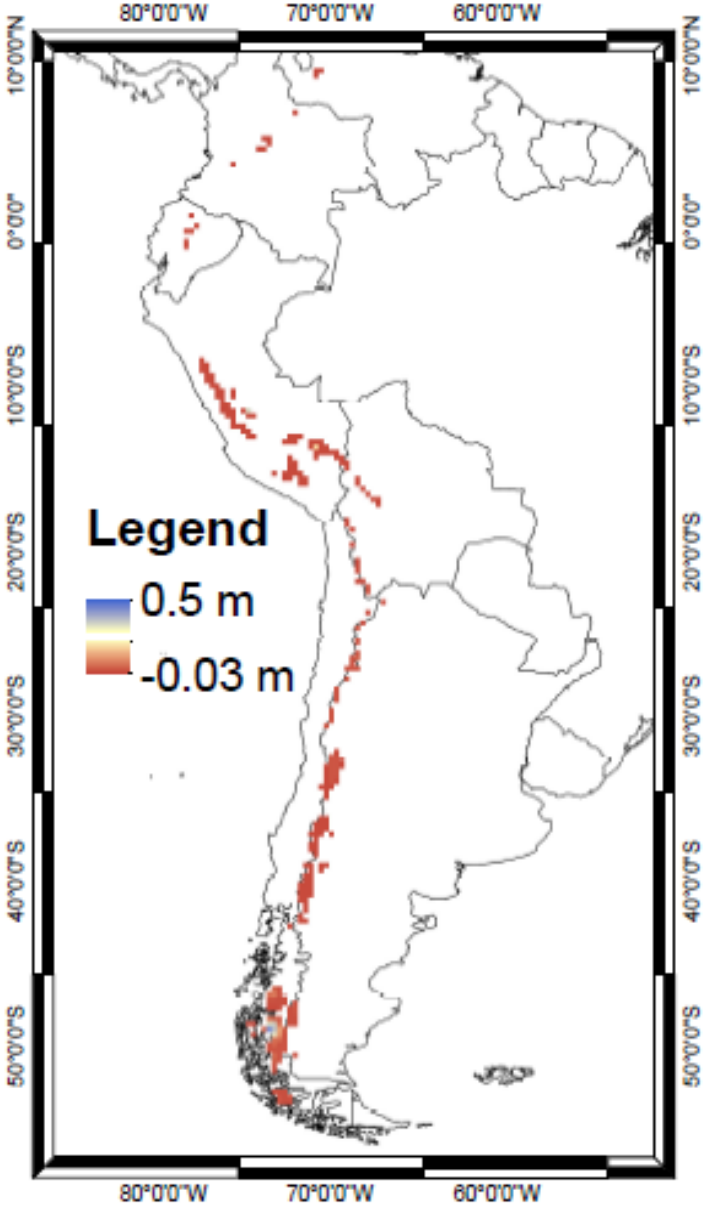


Some actual numbers

March 1979



March 2009



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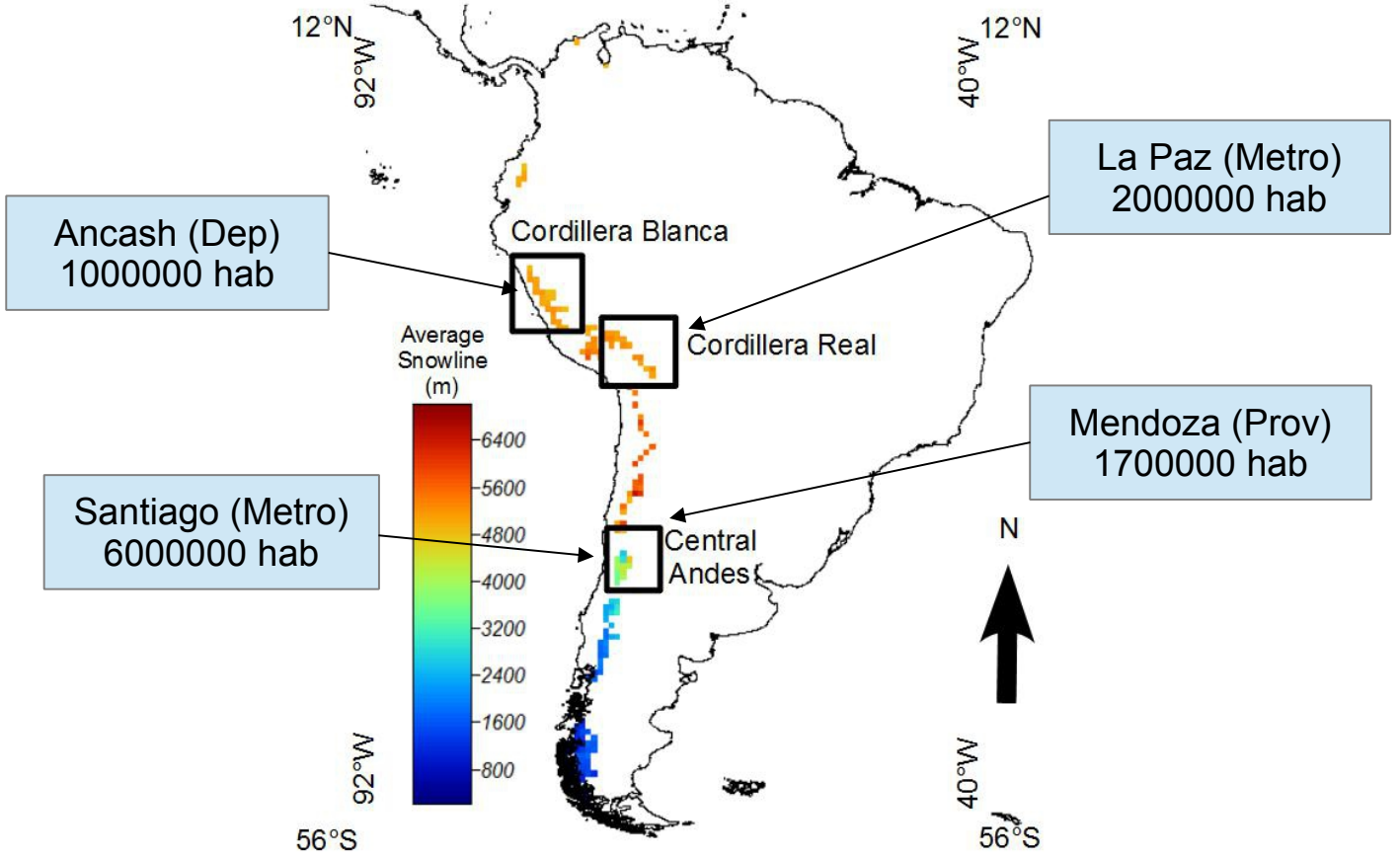
Using WRF (V3.4.1)

- We want to obtain 30-year climatologies to force our mass balance model.
- Focus on socially and economically relevant Andean areas.



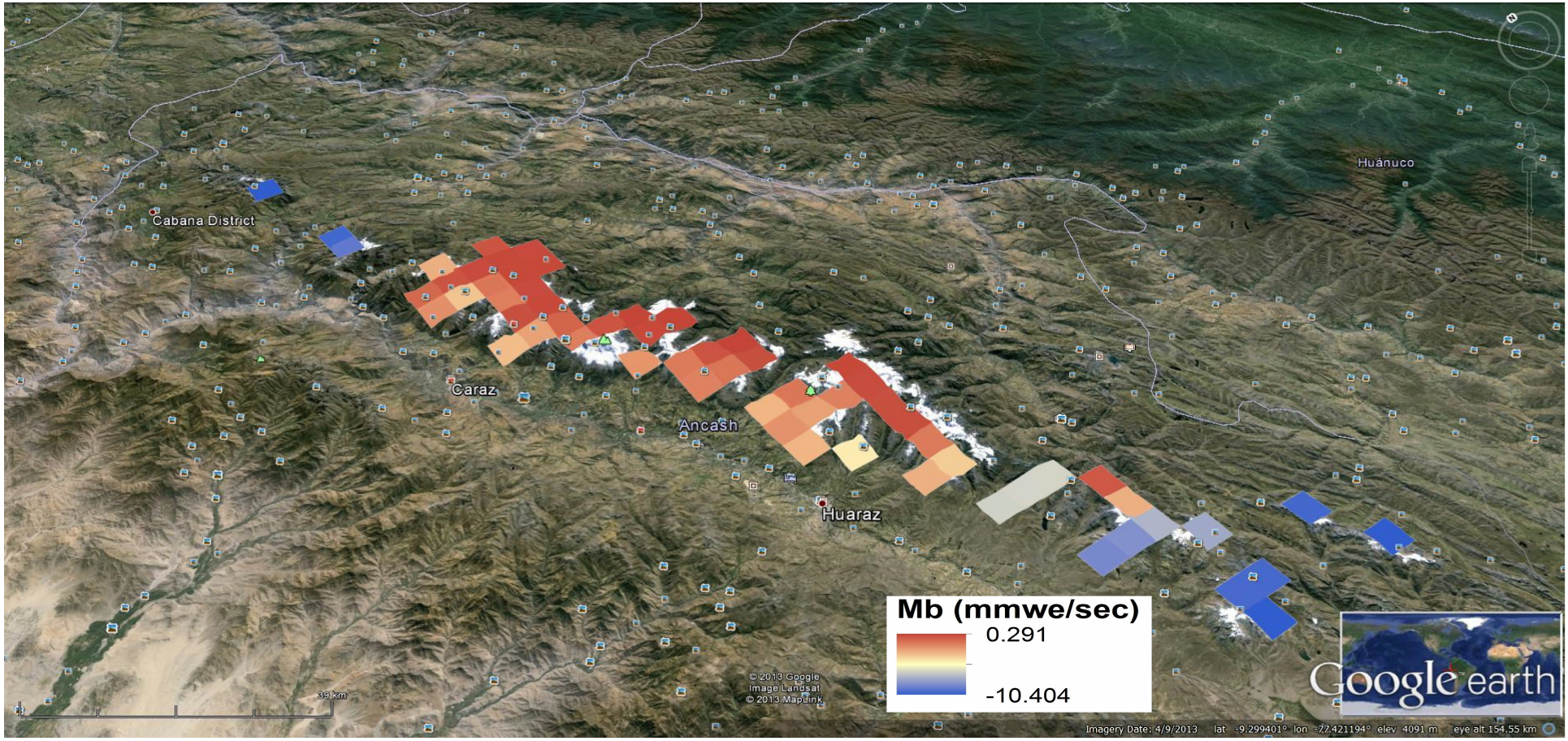
Using WRF (V3.4.1)

- CFSR and/or GFS as boundary condition

Number of domains	**Spatial resolution**	**Time step**	**Input data**	**Number of output**
4 (1 parent and 3 sisters)	~25 km (parent domain) ~5 km (nested domains)	Variable (150 to 60 sec)	CFSR/GFS	Twice (00 and 12) per simulated day
Microphysics	**Planetary Boundary Layer**	**Radiation**	**Cumulus param.**	**Land Surface Model**
WSM6 (parent only)	Medium range forecast model (MRF)	CAM (SW and LW)	Kain-Fritsch	Noah

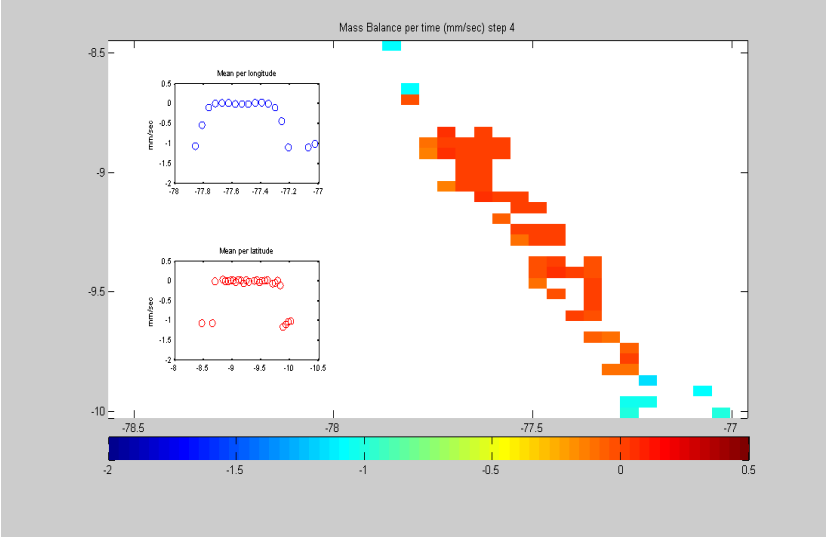
Mass balance using WRF output

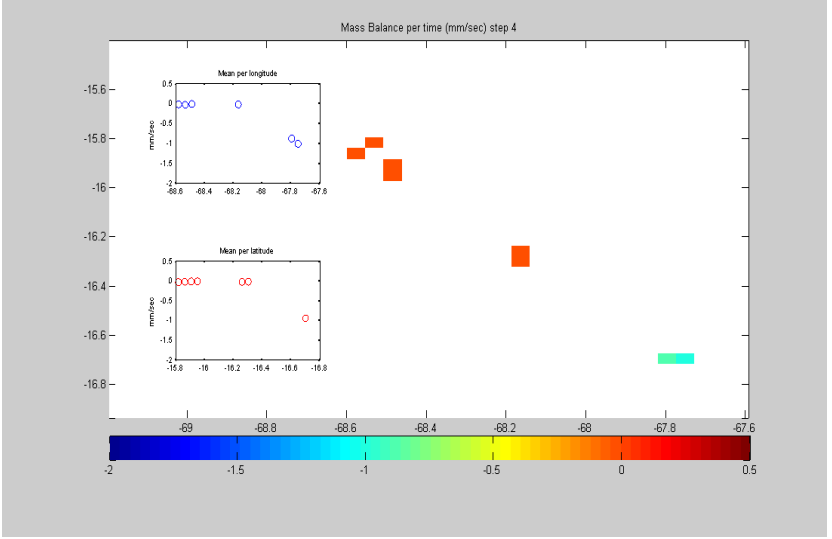
Cordillera Blanca, Perú July 2012



Mass balance using WRF output

Cordillera Blanca, Peru and Cordillera Real, Bolivia July 2012





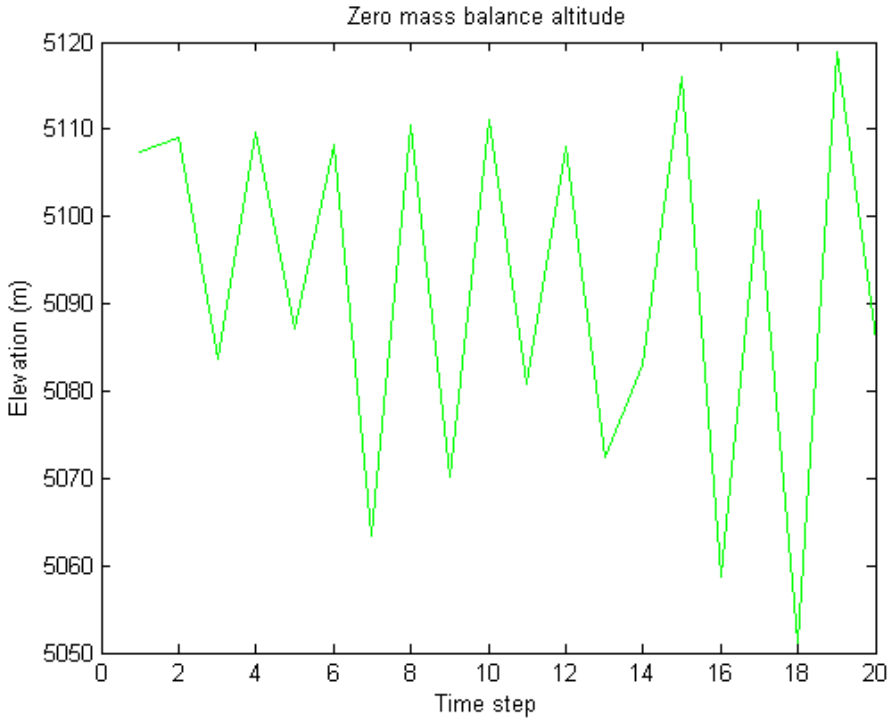
http://youtu.be/O-jRYQzI71M

http://youtu.be/b5b1s7fc6iU

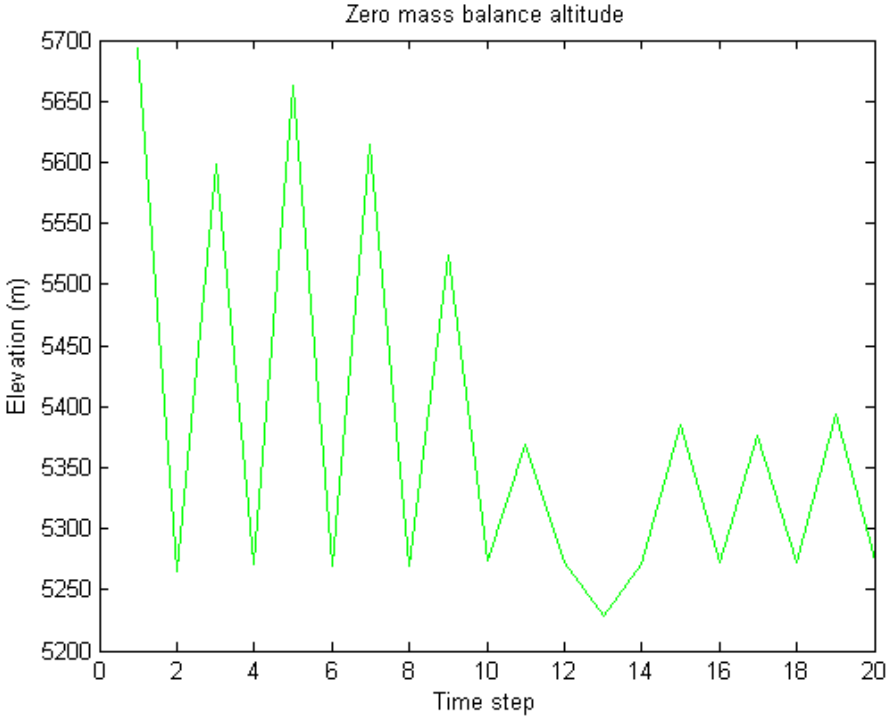
Mass balance using WRF output

- Zero mass balance altitude: Simple linear regression

Cordillera Blanca July 2012



Cordillera Real July 2012



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Some final comments

- Mass balance modeling on the Andes is necessary, but scarce and unorganized so far.
- Not every model is useful, though. Temperature lapse rate is the main driver of uncertainty. So, DDF is not recommended.
- Energy Balance models seem more accurate everywhere.
- On the continental scale EBM-CFSR shows a better performance. Possible effect of better resolved processes by the GFS model.
- Using CFSR realization as “Ensemble” may shed light on the mass balance on unsampled locations.
- CFSR-WRF-EBM is a good choice to model glacier mass balance at higher resolution.
- However, this is not an one-size-fits-all situation. Need for downscaled climatology to relevant spatial resolutions (1 km for C. Real perhaps).
- Another alternative may be to iteratively calculate time-varying lapse rates using variables at different pressure levels (Wind, T, etc.).

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