Introduction to Hydrologic Forecasting
An Atmospheric River Case Study

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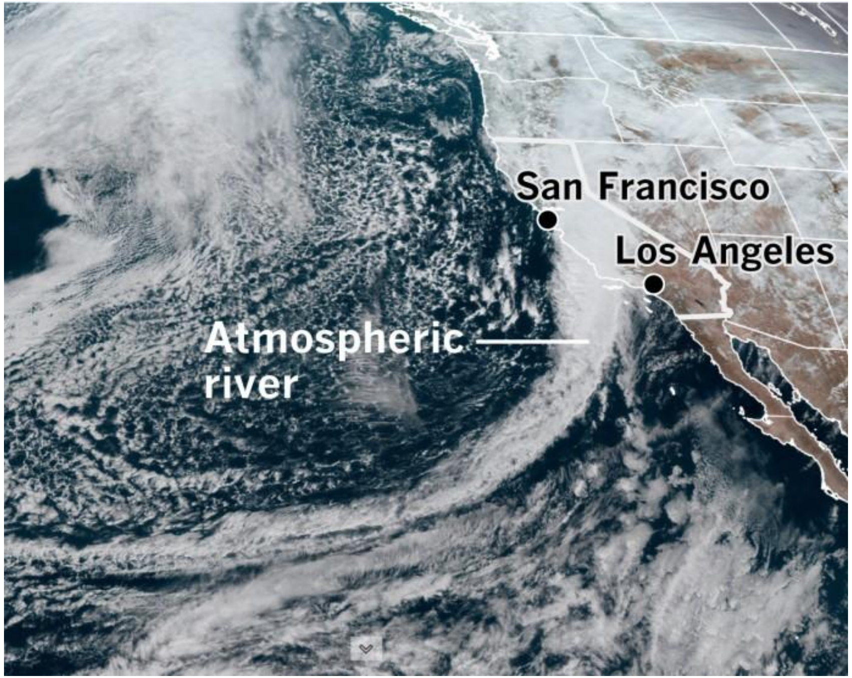

Image credit: NOAA

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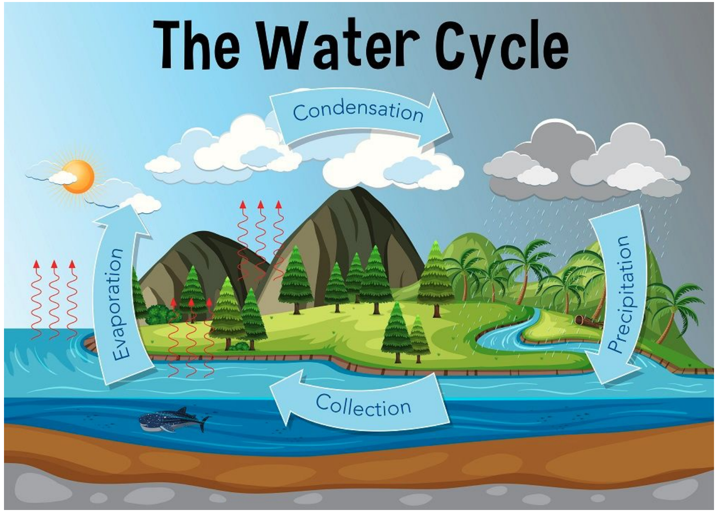
Background/Introduction



- River flow forecasting is critical for:
  - water management
  - hazard management
- River forecasts involve:
  - an atmospheric model, that predicts precipitation rates
  - a surface hydrology model, which predict river flow

Basically, they capture the most of the water cycle

Background/Introduction

For California, Atmospheric Rivers are an important weather type.

Atmospheric Rivers:

- deliver the majority of the state's winter precipitation
- can cause dangerous flooding.

So: we are studying rivers in the sky and rivers on land!!

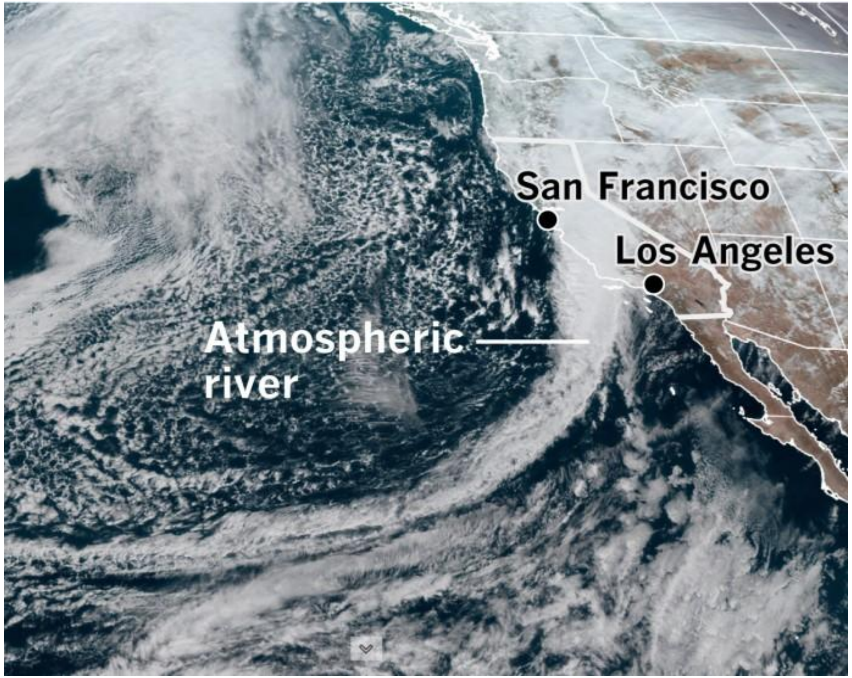


Image credit: NOAA

Motivation and Objective

- California is on the news alot for weather extremes (and I was curious to see what is going on!)
- Another motivation: we want to help people understand how river forecasts are created.

This presentation explains hydrometeorologic forecasting using a case-study of an atmospheric river that occurred Jan 5 – 10, 2017.

In our presentation we introduce:

- physics of the atmosphere related to winds and pressure differences
- details and limitations of precipitation measurements
- links between the storm in the atmosphere and the river flow

Data and Methods

Data analysis and visualization tool: Octave and Matlab (code on right)

Sea level pressure and water vapor data

- Reanalysis: a global weather forecast model improved with observations

Precipitation

- IMERG (top) - GPM constellation: combination of satellites from different organizations, i.e. NOAA, NASA, etc.
- QPE (bottom) - Quantitative Precipitation Estimate: NOAA NWS, combination of ground-based observations, radar, and satellite

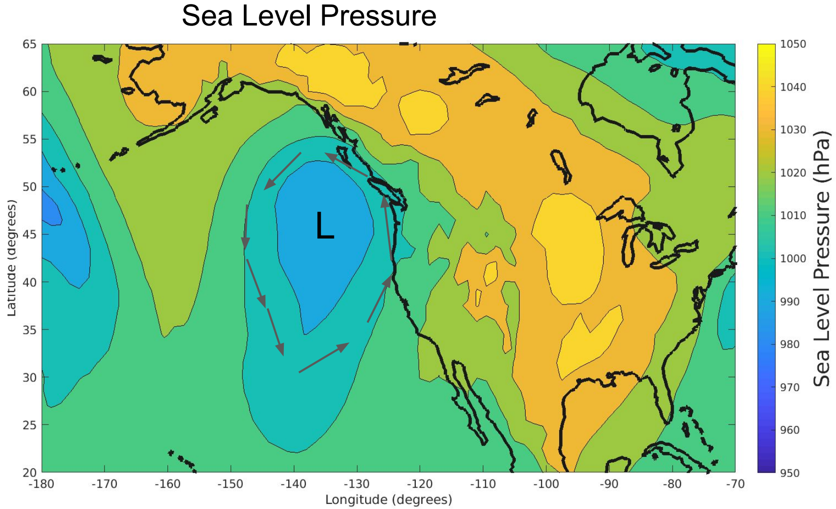
```
% load some data
load('Jan11_2017_slpmatrix2.mat')


% create a new figure
figure;

% plot the data.
% notice the shift of longitudes.
contourf(lon,lat,slpmatrix2)
shading interp
hold on

% plot the coastlines
plot(coastlon,coastlat,'linewidth',3,'color',[.1 .1 .1])

% Set the region !!! change this as needed.
axis([-180 -70 20 65])
cb=colorbar
cb.Label.String='Sea Level Pressure (hPa)'
cb.Label.FontSize=18;
daspect([3 2 1])

maptitle=['Sea Level Pressure ',slpdate2];
title(maptitle)
xlabel('Longitude (degrees)')
ylabel('Latitude (degrees)')
caxis([950 1050])
print('-dpng',maptitle)

% !!!! saving the figure
%figure_name='slp_jan_08';

% uncomment this line to save.
%print('-dpng',figure_name)
```

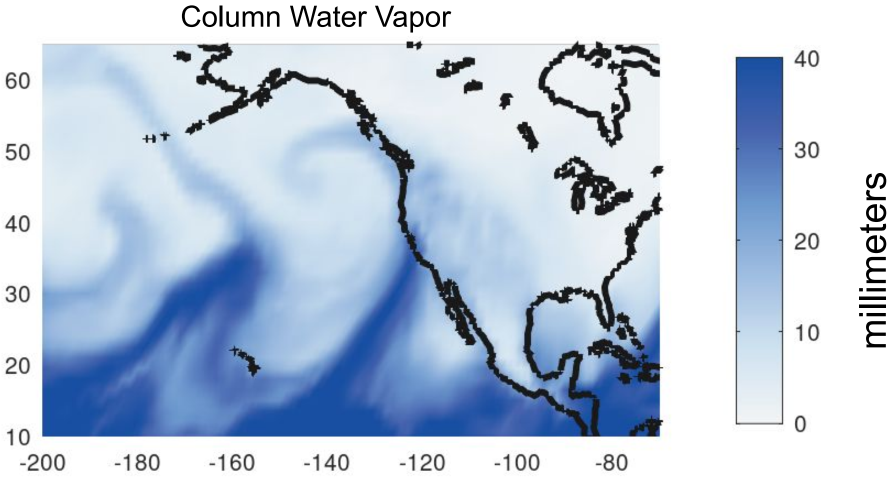
RESULTS

Flow and Moisture Transport

January 8, 2017

- Low pressure off west-coast of U.S.
- Geostrophic (pressure-following) winds go CCW around a low in NH
- Winds are from the south
- Moist air from subtropics is funnelled into region: atmospheric river!
- Comma shape is example of an extratropical cyclone

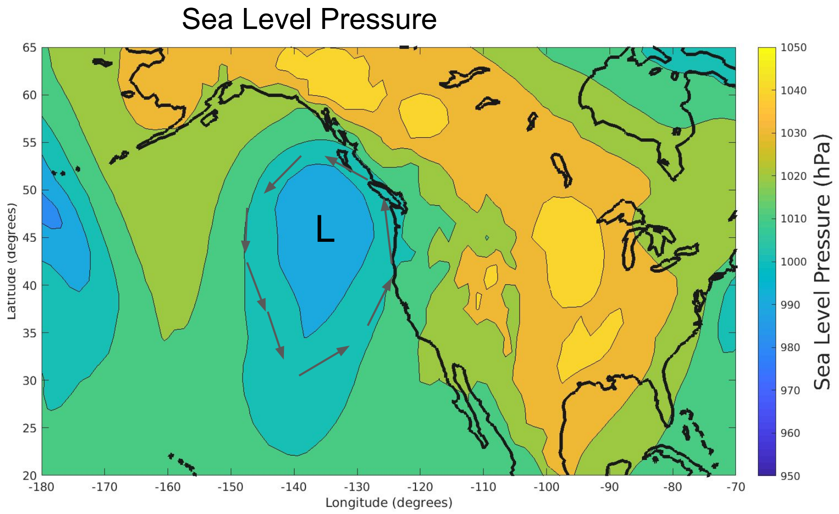


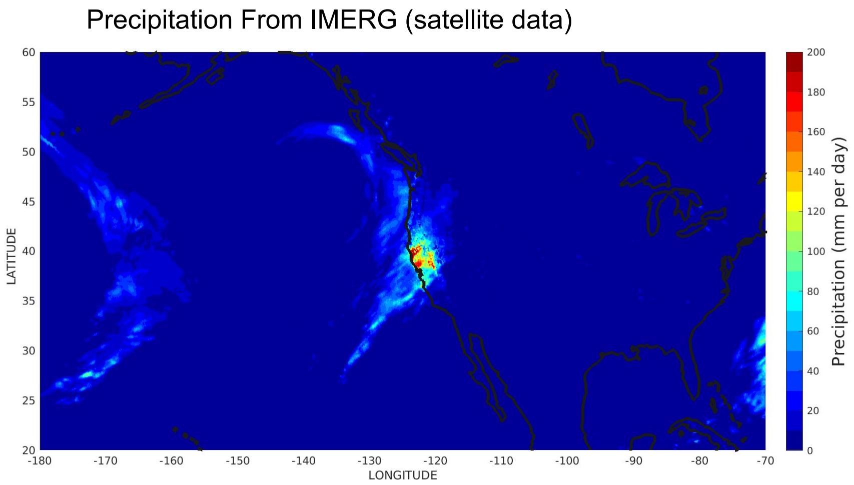


Flow and Moisture Transport

January 8, 2017

- Low pressure off west-coast of U.S.
- Geostrophic (pressure-following) winds go CCW around a low in NH
- Moist air from subtropics is funnelled into region (atmospheric river)
- Heavy rainfall





Comparison of Precipitation Products

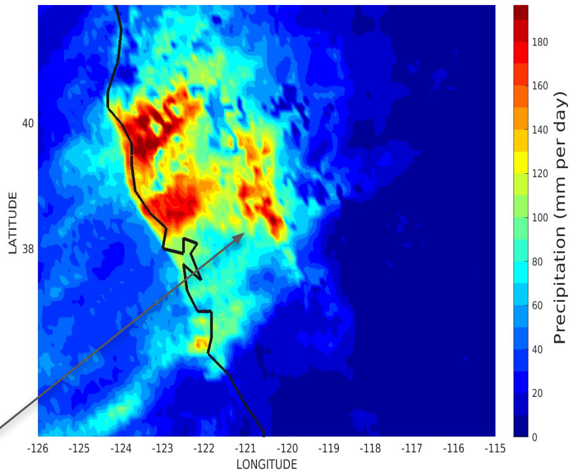
January 8, 2017

- IMERG captures precipitation over ocean, whereas QPE doesn't
- QPE is based on ground observations - for the locations with rain gauges, it is more correct. In other locations, either one might be correct.

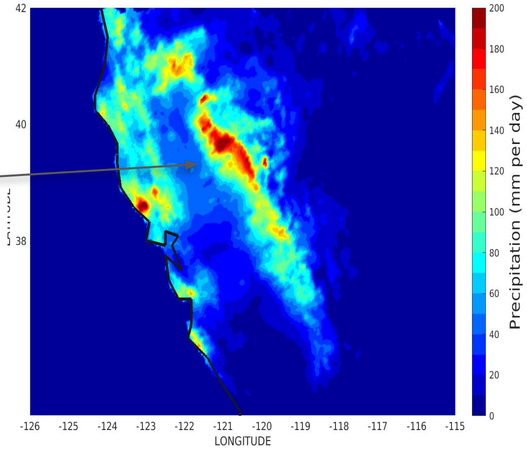
We can see the mountains

Take home message: no precipitation measurement is perfect.

IMERG Precipitation (Satellite)



QPE Precipitation (ground-based)

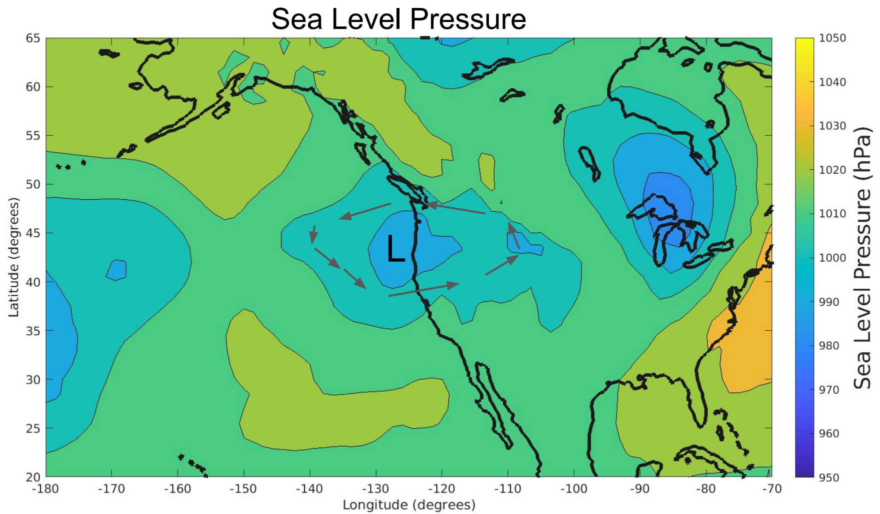


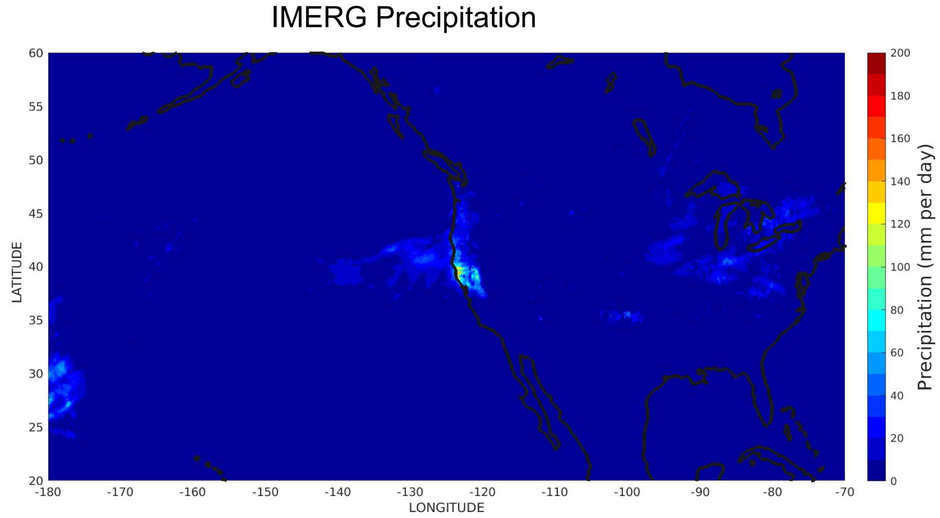
Note: the color axis for these two plots is identical

Looking at the Atmospheric River two days later.

January 10, 2017

- The Low Pressure has moved
- Winds are from the west
- The precipitation has changed as well
- Downstream (to the east) there is a large high pressure system





Results

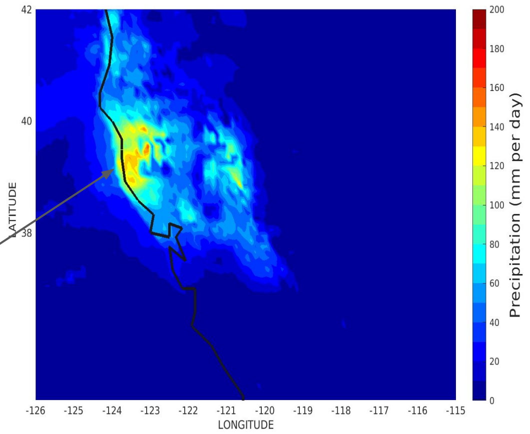
January 10, 2017

- Precipitation in both products is not as intense

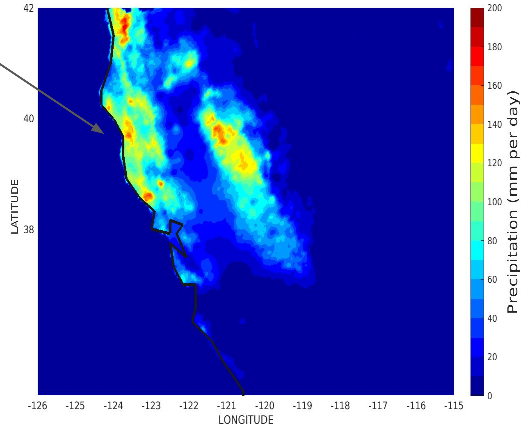
- There is more precipitation near the coast and less in the mountains

- QPE (bottom) is more intense than IMERG (top)

IMERG Precipitation (Satellite)



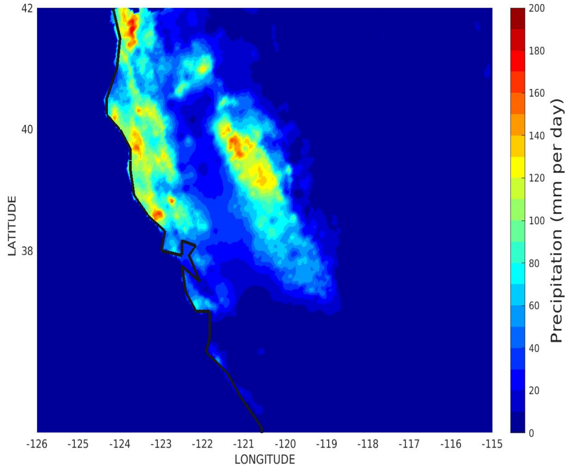
QPE Precipitation (ground-based)



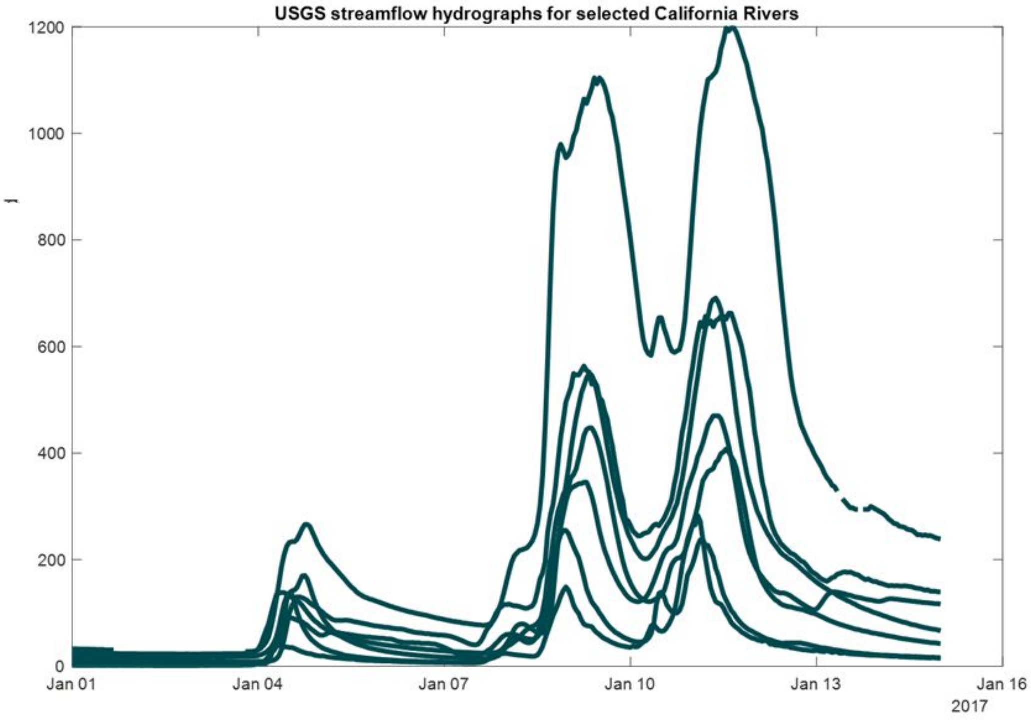
Note: the color axis for these two plots is identical

River Flow- How the rivers reacted to this precipitation

Each line represents the river levels for a different location within the area it rained



Rain



River levels go up

Conclusion/Discussion

- Physics of the atmosphere related to winds and pressure differences
  - Geostrophic balance
- How extratropical cyclones connect with geostrophic winds and atmospheric rivers
- Details and limitations of precipitation measurements and its effect on river forecasting
- Links between the storm in the atmosphere and the river flow

Photo credit: Louis Vest

References

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