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Making Research Actionable: Adapting Hydropower Operations to Changing Hydrology

2017 IEPR Joint Agency Workshop on Climate Adaptation and Resilience for the Energy System. August 29, 2017

Gary Freeman, Principal, PG&E

Together, Building a Better California

Suggested Research Focus

Climate change challenges for hydropower operations.

Declining snowpack

- Loss of water storage
- Uncertainty in remaining flow

Climate change impact varies north to south

- Elevation
- Geology

Variability and extremes in seasonal weather

Warmer temperatures can impact opportunities for cloud seeding

1) Better Defining Hydrologic Model Input

Research and Develop Physically Based Models Vs Statistical Models

Better define snowpack

- NASA/JPL's Airborne Snow Observatory
- Other Remote Sensing/Satellite Products
- Wireless Sensor Networks

Better understanding of evapotranspiration

- Soil moisture accounting

An Airborne Snow Observatory flight over the Tuolumne River basin.

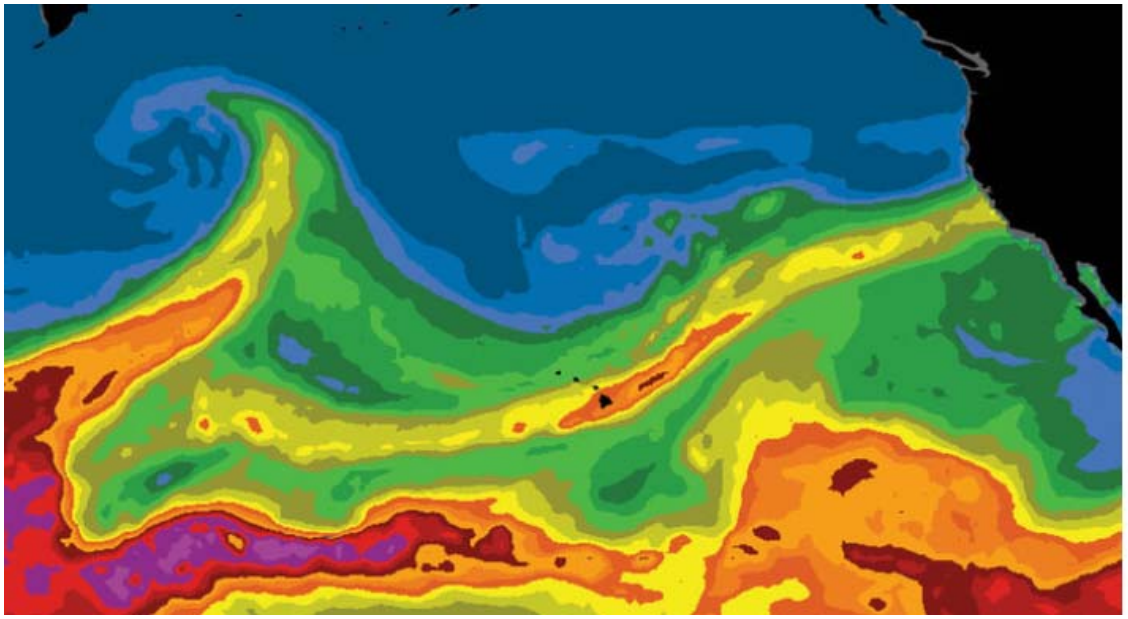
- Photo courtesy of NASA Jet Propulsion Laboratory

2) Reducing Weather Uncertainty

Research projects to improve weather forecasting

Frequency and Magnitude of Atmospheric Rivers

- Increased reliance on remaining seasonal weather
- Improved longer range weather forecasting to provide more certainty of remaining seasonal inflow

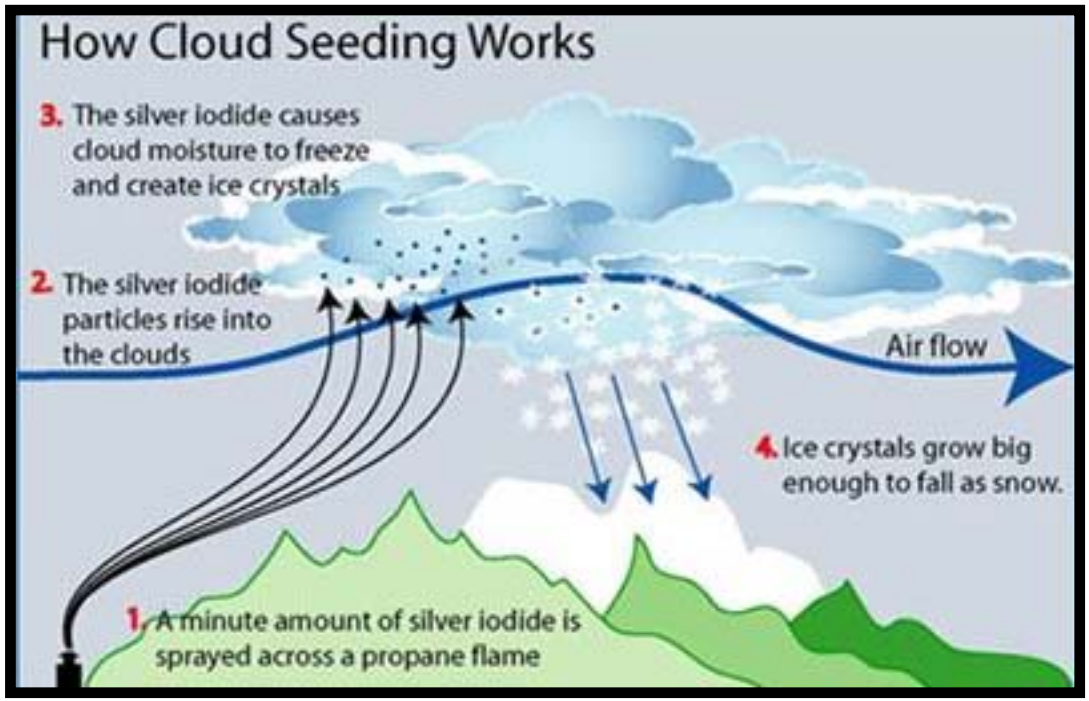


February 27, 2017 *(NOAA Earth Sciences Research Laboratory, Physical Sciences Division*

3) Precipitation Enhancement and Opportunities

Opportunities for Additional Cloud Seeding

- Aerial versus ground seeding
- Precipitation enhancement alternatives



Summary

Research Opportunities supporting Climate Change Adaptation for hydropower operations

- Enhanced hydrologic modeling with improved snowpack measurement
- Improved weather forecasting including atmospheric rivers research
- Additional cloud seeding research

Thank you

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