Planning Satellite Swarm Measurements for Earth Science Models: Comparing Constraint Processing and MILP Methods

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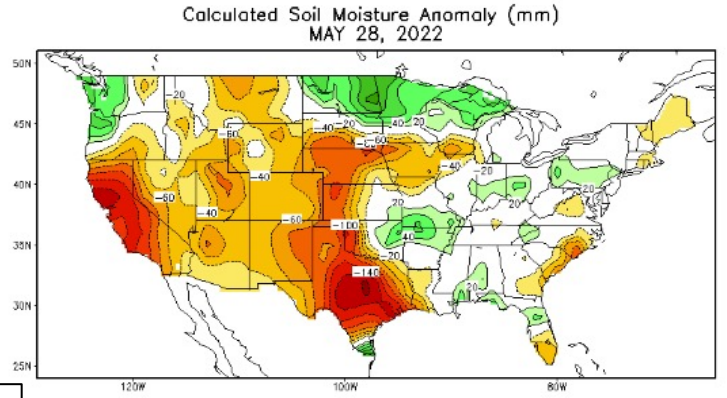


Application: Soil Moisture Prediction

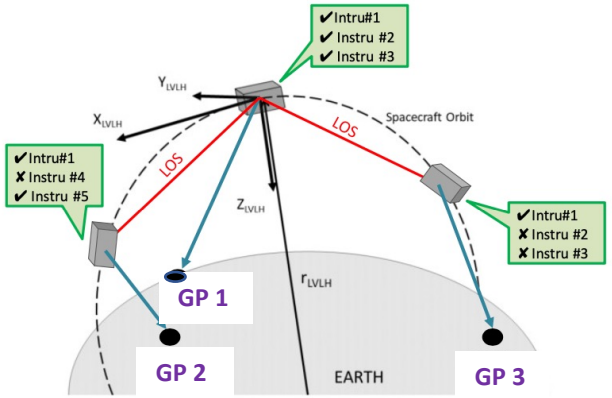
- Soil moisture is a key indicator for predicting floods, mudslides, wildfires, other phenomena
- Objective: Reduce soil moisture prediction errors
- Observe the **Ground Positions (GP)** which have *most prediction error*, using *sensor options with least measurement error*

Problem:

- We have initial solution for improving soil moisture prediction using constraint processing which follows a narrow beam of heuristically guided trajectories through a **huge** search space
- We don't know how optimal our heuristic solution is.

Research Questions:

- How close to optimal is our heuristic solution?
- Can we model our constraints in MILP?
- Can MILP prove optimality on our 6-hour plan horizon?
- How long would it take to prove optimality?



Goal: Apples-to-Apples comparison of Constraint Programming vs. MILP with identical inputs, constraints and objective

***Dynamic* Constraint Programming (DCP)**

- *Suboptimal but Fast*
- *Variables dynamically removed by constraint handlers*

Mixed Integer Linear Programming (MILP)

- *Optimal but Slow*
- Less flexible constraint modeling
- Scalability challenges

Huge Search Space

- ~ 8700 decisions /6 hr plan horizon
- ~ 55 cmd choices/decision
- # nodes in search space: **~ 55^{8700}**

Results: DCP = ~ 60% optimal Cases 1-5, MILP cannot optimally solve Case 6 in 50 hrs, but DCP solves it in 28 min