Goals: Climate Change Teach-In: What does Computational Complexity say about climate change? Describe "Games" using languages Start Proof that TQBF is PSPACE-Hard (is-there a satisfying assignment) (can player 1 win) PSPACE - James det: Quantified Boolean Formula  $\exists u_1 u_2 : \forall u_3, \exists u_4 \forall u_5 u_6, ((u_1 \vee u_2) \Lambda(u_3 \vee u_4)) \vee (\neg u_1 \Lambda(u_2 \vee \neg u_5)) = 0$  $\exists u_3 \forall u_1 \exists u_2 (u_1 \wedge u_2) \vee (u_1 \wedge u_2) \rightarrow (u_3 \wedge u_1)$ Game: I choose I values, you choose Y values Me You Me
Us
F
F
T
T
Woul If I can always make True > QBF is True - OBF is False Murmse J Spot to put X S.E. Y Places TOBF = S(X): X describes a true QBF ? TOBF IS PSPACE-Complete 1. TOBF E PSPACE 2. HLEPSPACE LEPTOBF => PSPACE-Hard polytime reducible. g = Q,U,Q2U2Q3U3 ~~~ Qnun P(U1,U2,U3,...Un) Qis exhart you Boolean formula M, LM m is imput length Solve QBF(q) O. If g has no unassigned variables:

Return evaluate (4) = o(m)1. 91= Q2 U2 Q3 U3 ... Qn Un P(T, U2, U3, ... Un) O(M) 2. Boolean (ans<sub>1=1</sub> & Solve - QBF (g<sub>1=1</sub>) ← O(1) + S(M, n-1). 3. Erase workspace used by  $4. Q_{1}=F Q_{2}U_{2}Q_{3}U_{3}...Q_{n}U_{n}Q_{F}U_{2}U_{3}...U_{n}$ 5. Booloan ans<sub>1=F</sub>  $\leftarrow$  Solve - QBF( $q_1=F$ )  $\leftarrow$  O(1) + S 6. Evase workspace used by Return ans 1 = F 2. 5(mn) = space used on input of Size M with N Unassigned Reform ans 1= F Variables. => Recorrence Relation  $S(M,N) = \begin{cases} O(M) & \text{if } N=0 \\ O(M) & \text{s}(M,N-1) & \text{if } N>0 \end{cases}$ S(M,N) = O(M) + S(M,N-1)-0(m)+0(m)+S(M,N-2)O(Mn) 40(M2) Input size is m